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PROJECT REVEIWS

Project Title: CIFT -- Production and Marketability of Edamame in Ohio

Project Summary

The following information describes the results of the project coordinated by CIFT to assist in establishing a guide for the production and the evaluation of the economic potential for growing edamame in Ohio. The results of the project address selection of seed, planting parameters, harvesting requirements (and alternatives if impediments negatively impact progress), optimization of storage techniques, processing, and the development of business opportunities that appeal to the market. A comprehensive evaluation incorporated the use of market research and interviews with key players, and focused on a number of elements including method of processing (i.e. shelled or in pod), cost to process, harvesting procedures, packaging, along with consumer preferences and potential for growth.

The word, "Edamame" originally means "beans from the branch" in Japanese---Soy beans grow in a cluster with stems connecting the pods, and the interest in and opportunities for edamame continues to thrive in the United States. In 2010, the U.S. imported an estimated 100,000 tons of edamame, mostly from China, with some imported from Taiwan, and according to the Soy Board, edamame will surpass all other soy-based products by 2020. Although not everyone in the U.S. is familiar with edamame, demand is growing rapidly, and as the U.S. is the number one soybean producer in the world, it makes sense to many growers here to devote some of their soybean acres to edamame, to capture this expanding market.

Among consumers, protein as a macronutrient has positioned itself in the spotlight, and increasingly, consumers are choosing plant-based protein sources like edamame as an alternative to animal-based sources for their protein. In 2015, one estimate suggests that the global protein market's value would total $24.5 billion. The estimate also projected that annual growth would be strongest for plant-based protein ingredients. Several factors have contributed to this interest in plant protein, including the expense associated with animal-derived protein, the intention to reduce animal-derived protein intake, the interest in clean eating and finally, the trend towards ingredient sustainability. Food processors use specialty soybeans to produce food products, including tofu, miso, soy sauce, natto, soymilk, tempeh, soy nuts and bean sprouts. Depending on the market opportunities for each product, soybean processors are starting to consider adding food-grade processing to their business models, in order to deliver these food-grade products like edamame to consumers. An Arkansas company successfully began growing and processing edamame with the result of increased profits for farmers and businesses and increased employment in the area. Edamame processed at the facility supplies the U.S. as well as international markets. Ohio has the potential to follow suit.

This project helped confirm that Ohio has the conditions required for edamame growth. In addition, the project provided outreach and education through established CIFT and partners' networks, including direct communication with growers, retailers, wholesalers, and foodservice outlets, about the market appeal for this plant-based protein. The overarching goal was to provide growers technical information to accelerate the expansion of the edamame industry in Ohio, and to capitalize on consumer demand for local, plant-based protein, and healthy food.

Although the edamame crop planted for this project was unable to be harvested due to inclement weather conditions, the market research, including interviews with key stakeholders, was still able to provide Ohio growers with the technical information necessary to make business decisions about whether to grow edamame here. Vegetable soybeans (edamame) are the same species *(Glycine max)* as field soybeans but for over 2,000 years have been specially bred to produce larger seeds, sweeter flavor, creamier texture, and easier digestibility. Edamame soybeans are easy to grow, however the weather must cooperate with enough rainfall. For this project, CIFT partnered with a local farmer near Grand Rapids, Ohio who agreed to grow edamame on a ¼ acre plot on his farm. To grow edamame, the soil should not be hard and the pH should be adjusted (if necessary) to 6.0-7.5. Good soil drainage helps seed to germinate, and it was determined that the plants need to receive 10 hours a day of direct sunlight. Based on previous research, water requirements are typically one inch per week, and depending on rainfall, a deep soaking once a week into the soil is recommended. Unfortunately, the summer of 2016 provided too little rain for this edamame crop to thrive. However, in reaching out to farmers who have had success in growing edamame in Ohio, interviewing other critical players including retailers, researchers, and plant breeders, and conducting market research, the goal of providing technical information about growing edamame so as to enable growers to make informed business decisions about this prospect was accomplished.

For the purposes of this initiative, and as a result of the uncooperative weather, a slightly modified methodology than originally planned, was employed. This included interviews among growers, industry professionals, retailers, and plant breeders, along with extensive market research. The results accomplish the goal laid out: to provide growers with the technical information necessary to make informed business decisions when evaluating production of edamame.

Project Approach

Through collaboration with a grower in Grand Rapids, Ohio, a ¼ acre plot of land was planted with BeSweet edamame seed on May 28, 2016, with plans to harvest around the week of August 21, 2016. The harvest did not happen due to lack of rain, but the project objectives were accomplished by modifying the approach. Below is a picture of the crop in early July. Even at that time, there had been little rain and the forecast was not encouraging.

Three main focus areas were applied to this initiative. Activities and results are noted for each:

A. Production techniques and post-harvest handling

This activity involved identifying, demonstrating, and evaluating the production practices and handling requirements unique to this crop. Unfortunately, as mentioned, Mother Nature did not cooperate, and while cultivars were selected, a local grower was chosen who enthusiastically agreed to partner for this project and plant ¼ acre of edamame on his farm, and the crop was monitored by him and CIFT from May to August, the lack of water throughout this period made the harvesting of the edamame unviable. Nevertheless, through research and interviewing of a number of growers, industry experts, retailers, plant breeders and others, the goals of this project, mainly to determine whether there is a viable market in Ohio for growing edamame, were met.

1. Selection of cultivars applicable to rowing in Midwest

Edamame cultivars vary in terms of plant height, yield, seed size, seed flavor, and time to maturity. These cultivars should be purchased based on "maturity group." This designation (0 to V) identifies the production region (latitude) for maximum yield potential. Edamame beans are harvested approximately 75-100 days from planting, but in Northwest Ohio, the ideal number of days to maturity is 85, and the maturity group and best seed variety for the climate, according to a local plant breeder and expert, is the Be-Sweet 292 variety, which is what was planted for this project. Fifty pounds of this seed were purchased, at $8.50 per pound. Following is a table which lists the best varieties of cultivar, along with each seed's days to maturity and expected yield. As mentioned, for the Ohio climate it was recommended by a plant breeder that the BeSweet 292 variety be utilized for this project:

Table 1: Varietal Comparison

Variety	Days to Maturity	Yield
Early Hukucho	75	Medium
Beer Friend	75	Medium
Lucky Lion	80	High
Green Legend	80	High
Envy	80	High
Gion	80	High
White Lion	90	High
BeSweet	90	Very High
Taiwame	90	Very High
Butterbean	100	Very High
Shironomai	100	Medium
Shirofumi	100	High

Table 2: Edamame Seed Supply Companies

Seed Company	Telephone	Web Site
Evergreen Seeds	**714-637-5769**	**www.evergreenseeds.com**
Fedco Seeds	**207-873-7333**	**www.fedcoseeds.com**
Garden Guides	**800-274-0824**	**www.gardenguides.com**
Johnny's Seeds	**207-861-3900**	**www.johnnyseeds.com**
Rupp Seeds	**419-337-1841**	**www.ruppseeds.com**
Territorial Seeds	**541-942-9547**	**www.territorialseed.com**
Wannamaker Seeds	**803-874-3011**	**www.edamameseed.com**

2. Collaboration with local grower to conduct test plot

CIFT collaborated with a grower in Grand Rapids, Ohio, who had experience planting edamame in the past. For this project, he planted ¼ acre of edamame. The field was well-drained and had a pH range best suitable for edamame, which is 6.0 to 7.5. Regarding terms of planting layout, research and grower experience indicated that closer spacing within the row does not increase pod yield, but does cause less uniform bean maturity. Spacing between rows was between 1.5 to 2.5 feet, and spacing within the row was three inches. The seeds were planted one inch in depth and there were about 400 beans planted per 100 feet. Based on previous experience, if planted too deep, or if there is too much rain after planting, the seeds will rot instead of germinate.

3. Monitor performance in growth and timing associated with harvest

Edamame has similar growth and development characteristics as traditional soybeans, with growth duration depending on the maturity group. Our ¼ acre plot was planted on May 28, 2016, with the expected date of harvest to be around the third week of August – approximately 85 days. The plants sprouted and grew as expected, but by the second week of August, when the pods were not fully formed and swelling, it became evident that due to lack of irrigation, they would not be able to be harvested. Irrigation is essential, especially (if there is insufficient moisture) at flowering and pod-filling stages, and at these two times, there was little or no rain. The picture below shows the edamame in early-July. The grower at that time stated that rain was needed in order for the crop to be successfully harvested.

4. Identify the equipment needs related to harvesting and cooling of the product in the field or immediately upon removal

The best time to harvest (and one of the challenges of growing this crop) is when most of the beans are bright green, tender, plump, and the pod is swelling, which is just before pods begin to turn yellow. And it is critical to get the timing right, because once the pods begin to turn color, it has almost become too late to harvest the edamame. To determine, pick a bean and hold it up to the sunlight and beans should fill out the pod and swell. This is the R6 stage of soybean maturity, when the sugars and amino acids required for good taste are at their peak. To harvest, plants are either pulled or cut at ground level so that the pods at the lower nodes are recovered. As mentioned, there is a short window of time for harvesting best-quality edamame. If the pods start to turn yellow it is too late to harvest. Taste deteriorates quickly and the flavor becomes starchy. Immediately upon harvesting, the product needs to be brought to a cool place and quickly refrigerated, to preserve freshness. A few pods will be too immature and others will be too old but the majority should be acceptable if the timing is right. If the edamame is going to be sold fresh, it cannot travel more than 5-8 hours, according to several of the growers. A number of retailers and farmers mentioned that they have their edamame picked at the peak of ripeness, and within 4-6 hours of harvest, the edamame are cleaned, shelled, blanched and prepared for packaging.

The harvest for this project was to have taken place the week of August 21, which was approximately 85 days from planting, and the beans would be closely monitored every day during the week prior to this date, to ensure that the beans did not start to turn yellow early. Because edamame can be harvested using the same machinery as green beans, these two vegetables make a logical pair for farmers to grow. To harvest, workers would be using a green bean mechanical harvester, adjusted to the edamame pods. It would be important for harvesting to take place in the morning, during cooler temperatures. Harvested pods would be placed in a refrigerated truck (using food grade crates or baskets), and brought to the processing facility immediately. Previous attempts by local growers were restricted due to lack of cooling equipment or proximity to a processing venue. This project would have utilized a cooperative kitchen facility with an IQF blanching and freezing operation. Once there, the beans would be sorted and cleaned as defined in the Good Manufacturing Practices of the outlet. Similar to that of green beans, the product would be held at cool temperatures and prepared for processing. Due to the lack of edamame available through the demonstration plot, green beans were used to simulate the approach. Following sorting for foreign materials and blemishes, beans are steam blanched. Upon completion of the designated

time and enzymatic evaluation, beans would be placed into an ice bath to remove the heat. Using ice ensures rapid removal and reduces the continued "cook" time otherwise experienced. Edamame is then placed on trays with air applied to remove excess water in an effort to limit crystallization when frozen. The Individual Quick Frozen (IQF) approach allows for minus 70 degrees to be applied in a matter of minutes, thereby by maintaining nutritional value and quality. The processing would require at least four workers and 8-10 hours depending on quantity.

It was expected that the harvest would provide approximately 1500 lb. of unshelled edamame for this project, so there would need to be enough room to process and store 30-35 bushels of beans. It was determined based on research and past experience that once the edamame was ready, it would need to be harvested within a 2 day period, at 500 lbs. per day, which would require 3 workers. One worker can typically harvest 200 lbs. per day. It was intended that 500 lbs. of the edamame was to be shelled, using a shelling machine, and the other 500 lbs. would remain in the pod. A green bean sheller provided by the farmer would be adjusted to fit edamame beans and utilized to shell half of the harvest at the processing facility.

Most edamame in the United States is imported for the frozen food market. Local US production for the fresh food market is growing, but is limited by harvest methods. Bean or edamame picking by hand is very slow and limits market growth for small growers. Equipment is available for large growers, but there are no small-scale pickers available for the thousands of small producers that are struggling to make a living by selling for the fresh market.

Edamame can be harvested with a mechanical green bean picker, but as mentioned, commercially available bean pickers are not economically viable for use on small farms. A used Oxbo pull-type bean picker can cost $20,000 and is approximately 16 feet long, making it too large to use on a small farm, as well as too expensive. Picking edamame and bush type green beans by hand is very laborious, not cost effective and not sustainable. Although demand is high and prices can be fairly good for edamame the selling price of a bean picker does not support the cost of harvest labor. Making edamame and bean production more feasible and productive for small growers will help raise farm incomes, keep small farmers in business, produce locally available vegetables and provide healthy foods to consumers.

To provide the ability to mechanically harvest edamame and bush beans, a proto type of a bean picker was designed and constructed specifically for small farmers. The design is semi-compact, relatively easy to build for someone with fabrication experience and easy to operate. The investment costs were minimal (far below $20,000) and many of the parts were machined by hand, but if the design is picked up by a commercial fabricator or replicated by other farmers, design modifications could allow use of commercially available parts, eliminating the need for custom machining.

To compare harvest speed, rows of edamame soybean were hand harvested and compared to the amount of time it took the bean picker to harvest a similar length row. Mechanical damage was also compared between the two harvest methods.

The machine picker is approximately 10 feet long (not including tongue) and hydraulically operated. The reel is designed to finger through the plants, pulling both the beans and the leaves onto the conveyor belt. The conveyor assembly uses two 12-inch ribbed belts and carries the beans

from the reel to sacks or a small wagon pulled behind the harvester. Because of cost overruns and time constraints, the winnowing fan was not put on the prototype. The wheels are adjustable so the user can move the conveyor closer or farther away from the ground. The harvester turned out a little large for growers with small edamame plots. Recommended size for this harvester is one acre or more of edamame or beans. Smaller growers may want to consider a table-top picker where whole plants are fed into the machine and pods are separated from the stem.

Parameters for measuring the success of the machine include changes in yield due to increased harvest capacity and decreases in amount of time spent on harvest. Hand harvested edamame requires about one hour to obtain 8 pounds. The edamame harvester picked 8 pounds of edamame pods in 2 minutes. Mechanical damage to the pods was less than 5%. The harvester is capable of picking an acre of edamame in approximately 5 hours compared to 871 man hours for hand harvesting one acre of edamame beans. It pulled approximately 95% of the pods off the plants.

5. Documentation of yields, performance, quality

Edamame does not yield like soybeans. Edamame plants typically do not produce as many pods but have a bigger bean. When edamame is harvested, the emphasis is on the pod numbers and the beans per pod (three or more is best) as opposed to the yield per plant, which is the main reason why harvesting of edamame is different when compared to the harvesting of soybeans. The soil type for edamame is also critical – it does not do well in heavy ground like clay. Overall, the Ohio conditions are amenable to the growth of edamame, as long as the weather cooperates. Length of the growing season is another important factor to consider, especially in seed selection. Some varieties have a short maturity time of 75 days while others have a longer maturation of 100 or more days. Most varieties are of a bush-type growth habit, which ranges from 1–2 feet tall. A few other varieties are more of a vine nature that would require trellising.

Yield varies with planting conditions and weather during the season. However, an average yield is .25 lb. of pods per plant. If growing larger quantities, farmers typically average 2.5 - 3.0 tons of edamame pods per acre. The yield of shelled edamame is about half the volume of edamame in the pod. Although the crop for this project was not able to be harvested, in terms of yield, we had anticipated a yield of ¼ lb. of pods per plant, which would equate to 2.5-3.0 tons of edamame pods per acre. The yield of shelled edamame is about half that. The ¼ acre that was planted for this study was projected to yield about 1,500 lbs. or approximately 30 bushels of edamame. Typically, a bushel of edamame contains 28-30 lbs.

6.Consideration of herbicides, insecticides, and similar production factors

There are several insect and other pests of edamame. Slugs are the major pest when plants are young if the field is infested. Pod borer is also an insect problem. Other arthropod pests include whitefly, leaf miner, aphids, mites, potato leaf hoppers and stink bugs. Pigweed species, including palmer amaranth and water hemp are two of a longer list of broadleaf weeds that are problematic for edamame. Two herbicides recently labeled for use on edamame, imazamox (Raptor, BASF) and fomesafen (Reflex, Syngenta), both used in soybean for years, were recently registered by the Environmental Protection Agency (EPA) for use on edamame. These new weed management options for edamame will help to reduce reliance on hand weeding and result in crop-production costs that are more competitive in the global market. Currently, hand-weeding costs can exceed $500 per acre, so more cost-effective weed management tools are important for making the U.S. more competitive for growing edamame.

7. Planting design so that that harvesting can be prolonged for more than 3 weeks
In Ohio, soils often warm sufficiently for planting by late May. In order to extend the harvest, the planting can be staggered. To do this, plant both a short 75–80 day variety and a medium 100-day variety at the same time. Wait about ten days and do this again. Such successive plantings can be made until 90 days before the first expected frost. Expect one pound of pods for 3–4 feet of row.

B. Methods of processing and market appeal
However the edamame is processed, it must be done quickly, according to all knowledgeable sources. Two sources mentioned it taking 4-6 hours to harvest, clean, shell, blanch and prepare the beans for packaging. Fresh, locally grown edamame is very appealing to consumers, but it is difficult to find, since over 90% of the product is imported from China and Japan. Plus, it does not store well, and growers can expect that harvested beans will retain flavor and appearance for only about one week, and that is if properly stored, i.e. kept refrigerated. There have been reported efforts to develop commercial-scale edamame production and processing in Pennsylvania, Ohio, and several other states, and 800-900 acres were successfully harvested in Arkansas recently, with plans by that state to double or more in size. The increase in demand and the strong market appeal among consumers for this excellent source of protein creates a huge potential for growth opportunity for famers of this specialty crop if food companies can figure out an efficient processing system for a crop that must be harvested and packaged quickly.

1. Evaluation of fresh vs. frozen processing and shelled and in-shell options
Edamame can be marketed as a fresh vegetable or as a frozen food. After harvest, the edamame can be sold to a processor for freezing or it can be shelled and sold to the local market. Some consumers, especially Asian consumers, prefer the edamame with pods attached to the stem, which brings a premium price. Edamame in some other states is often marketed directly to consumers through CSA shares or at farmers markets or farm stands. Grocery and natural food stores sometimes also sell fresh edamame. Frozen edamame can be found in large grocery chains and in smaller grocery stores as well. Most stores offer a variety of package sizes, from single serving size to bulk servings.

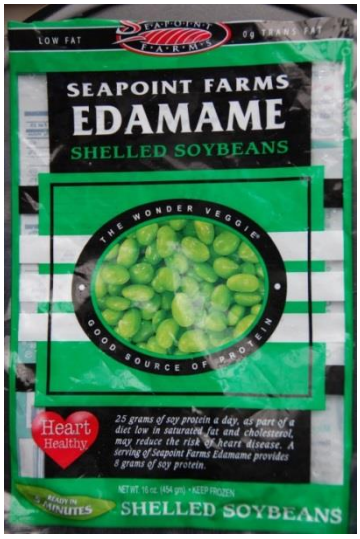
As for the shelled vs. in-shell options, shelled edamame has become popular to add to salads soups, pasta dishes, stir-fries, or casseroles, or can be served as a side dish like peas. In-shell edamame is a staple at Japanese sushi restaurants or, after boiling and salting, consumers can eat the beans directly from the whole pod (pods are not edible) as a healthy protein snack.

2. Protocol for blanching and freezing product to maintain optimum flavor
Blanching edamame before freezing stops the plant's natural enzymes from continuing the ripening process. If edamame are placed in the freezer without blanching, they will spoil faster. To freeze fresh edamame in the pod, the sorted pods should be cleaned by spraying water. Next, blanch by bringing a pot of water to a boil. Add edamame in the pod to the pot, bring back to a boil, and boil for about 2 minutes. Drain. Rinse with cold running water to cool or place in ice water. The pods are sorted again to remove all unqualified pods. They should then be taken through a quick freezer and quick frozen. The pods freeze without forming any large ice particles and thus suffer only minimal damage to the bean tissue. The frozen pods are stored in freezers until shipped in

refrigerated containers. The beans can also be shelled from the pods and sold or they can be frozen, packed, and sold.

3. Packaging considerations based on entry into the market i.e. bulk for foodservice

There are a variety of size and packaging options on the market for edamame. On several visits to grocery stores in the area, numerous varieties of frozen edamame packages were displayed. Packaging was typically a plastic bag containing the frozen product, but another type of packaging, a small cardboard box, provided a single serving of the product, with a venting capability in the box. The larger wholesale stores offered the product in separate plastic packages, contained in a cardboard box, so consumers could open one package at a time. Following are some package offering options for edamame:



Various Packaging Offerings for Edamame

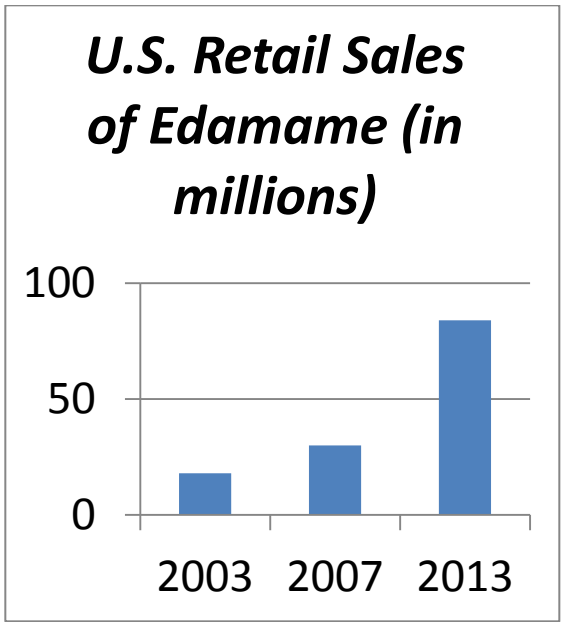
4. Comparative evaluation of the product already available

Several years ago this crop was grown and available fresh on the stalk at a local Northwest Ohio grocery store, and the store could not keep it on the shelves. According to the retail outlet that offered the fresh edamame at that time, consumers especially liked that that it was on the stalk, because that indicated that the product was extremely fresh. While it does not currently have fresh edamame on its shelves, this same grocery store has frozen edamame available in eight varieties (shelled and pod, in various sizes) offered by three manufacturers. Another local store has two manufacturers of edamame available. The local wholesale food outlet did not have edamame available on the day visited; however another local wholesaler typically sells the product in bulk. Currently, close to 90% of the edamame available in the U.S. is shipped from China and Japan.

In terms of marketing edamame, it is more closely related to marketing vegetables than conventional oilseeds. The current market in the U.S., aside from grocery stores where it is mainly available frozen, is associated with specialty produce and farmers markets located near population centers, in certain areas of the U.S. And as mentioned, frozen edamame is available in almost all of the major supermarket chains. The primary production areas for freezing edamame in the U.S. are on the West Coast and the Upper Midwest; although most is imported from Asia. Rising transportation costs have created an interest from some eastern U.S. frozen food packers in sourcing more edamame.

5. Collect consumer feedback on the processing techniques and desirability

Consumers are strong supporters of locally grown fresh food, and edamame is no exception. Research showed that consumers are willing to pay more for local produce, including edamame. In addition, Edamame is high in protein, low in fat, and has nutritional value to consumers looking for new and unique vegetables. Edamame is often boiled or steamed as a snack or added to salads or Asian cuisine. Based on the Consumer Attitudes about Nutrition survey, 28 percent of Americans consumed soy foods or soy beverages once a week or more in 2013 compared to 19 percent in 2006. Currently, 42 percent of Americans consume soy foods at least once a month. In addition, as depicted by the chart below, in 2012, Americans consumed between 25-30 thousand tons of edamame, and consumption is rising by 12-15% per year.



6. Economic evaluation compared to imported to the increased value gained from local
The demand for edamame in the U.S., especially organically grown edamame is increasing in health food and Asian markets across the country. Ohio growers may want to take advantage of the opportunity to grow a specialty crop that can fetch a premium price. Marketed fresh at farmers' markets, edamame bunches (whole plants with stems and pods) can go for more than $4.00 per pound. Fresh edamame pods (picked off the stems) sold wholesale to grocery stores bring the same price. Food trend experts and farmers say edamame remains a niche product but they see potential for growth for U.S. grown edamame if food companies can figure out an efficient processing system for a crop that must be harvested and packaged quickly. Plus, with meat prices rising, Americans are interested in less expensive, alternative proteins, and while soy has not historically been viewed as being an edible crop in the U.S., more people are becoming aware of Asian foods like tofu and edamame, as well as consuming more plant-based diets. This new diet inclination, along with a trend among cost-conscious consumers looking for alternatives to meat, opens up a wider market for locally grown edamame.

It's not clear how much edamame is being produced in the U.S. because the Department of Agriculture doesn't distinguish it from other soybeans. But most experts agree that the amount is currently small. And farmers who are testing the edamame market have mostly started small. One farmer who grows about 1/10 of an acre said, "*Growing* edamame is the same thing as growing a conventional soybean. It's the *harvesting* that's the difference." This is because, as mentioned earlier, once it's harvested, there is a very small window of time to get it processed before it starts losing its quality. The harvesting process has not been the only factor limiting growth of this crop in the U.S. Issues such as weed management (recently improved by the introduction of new herbicides as noted earlier in this report), limited seed availability and the need for better-quality cultivars have all been factors in inhibiting U.S. farmers from devoting more acreage to this specialty crop. Regarding the need for improved cultivars, there are issues pertaining to adaptation, disease resistance, taste, harvestability, seed size, seedling emergence, and vigor in developing. "The vegetable industry recognizes the growing consumer demand (for edamame) in

the U.S., but until more of these hurdles to domestic production of the crop are lowered or removed, I think they're going into it cautiously as they should," said Marty Williams, a University of Illinois crop sciences researcher and USDA-ARS ecologist.

Starting a new specialty crop is also a business risk for growers, but doing it on an existing farm makes the financing and development costs easier to absorb. Those growers who have been in the farming business a long time (sometimes for generations), consider planting a new crop like edamame as a startup within a generational farm, which allows them to capitalize on existing infrastructure, equipment and land.

C. Outreach and Education

1. Direct communication with retailers, wholesalers, growers, consumers, and farmers markets on the market appeal for this product.

a. Contacted 4 growers about planting edamame– 2 expressed interest and one grower agreed to partner with CIFT on this effort.

b. Interviewed the following for this project:

i. Four produce managers at local grocery stores
ii. One seed expert
iii. One wholesale company
iv. Four agricultural professors (U of Toledo, U of Kentucky, U of Missouri)
v. Eight growers who have experience with edamame

2. Shared with growers through meetings, electronic communication, presentations at industry events, outreach through OSC, and industry publications.

a. The project was promoted at every monthly CIFT Ag breakfast event in 2015 and 2016 (Averaging 30 per session)

b. Presentations about edamame growing and marketing given at the following locations to an average of 30 growers:
   a. Agricultural Incubator Foundation
   b. Ohio Department of Agriculture
   c. Wilmington College

c. The project was promoted to 120 growers via CIFT Newsletter.

d. Information was tweeted about through CIFT Twitter Account (over 1,000 followers) on many occasions.

3. Information published in OGA and ORA newsletters further introducing this as a viable product.

Final results of the project will be shared with OGA and ORA for consideration of inclusion in their respective publications. Additionally, the Ohio Farm Bureau Federation will be provided details on the initiative. Ohio Soybean Council showcased the potential for edamame previously and will be updated as to the insights gained through this evaluation and the potential for local processing.

4. Samplings will be facilitated to collect details on consumer prefer fences.
It was intended that samples would be provided to consumers for direct market evaluation and data relating to preferred packaging, processing, pricing, and overall product appeal. As mentioned earlier, crop failure prohibited this aspect and information was obtained from market research sources instead. There wasn't sufficient time to proceed with gaining consumer feedback based on a retail product by the time notification of unavailable fresh was received.

Goals and Outcomes Achieved
At the start of the project, it was anticipated that information would be shared on the website. However, as the initiative evolved, direct interaction was more favorable and insightful. When posting information on the website, it was not possible to provide direct benefit so alternatively, project updates were offered through presentations and email correspondence so that growers with specific questions could be accommodated more readily. General information was noted on the website resulting in requests from media outlets to do stories and that further generated interest from growers which resulted in three stories and expanded outreach through the publications.

Production techniques and post-harvest handling
This goal involved identifying, demonstrating, and evaluating the production practices and handling requirements unique to this crop. Nevertheless, through research and interviewing of a number of growers, industry experts, retailers, plant breeders and others, the goals of this project, mainly to determine whether there is a viable market in Ohio for growing edamame, were met.

Selection of cultivars applicable to rowing in Midwest
The goal of selecting the best seed variety for the Ohio climate was accomplished by research and recommendation from a plant breeder, who suggested that the BeSweet 292 variety be utilized for this project.

Collaboration with local grower to conduct test plot
CIFT's goal for this project was to reach out to and collaborate with a farmer who had experience planting edamame in the past. A grower in Grand Rapids, Ohio was identified and was willing to collaborate on the initiative.

Monitor performance in growth and timing associated with harvest
CIFT worked with the farmer and monitored the growth of the edamame, until it became evident that a harvest would not take place due to lack of rain. The grower at that time stated that rain was needed in order for the crop to be successfully harvested.

Identify the equipment needs related to harvesting and cooling of the product in the field or immediately upon removal
Through research it was determined that edamame *can* be harvested with a mechanical green bean picker, but commercially available bean pickers are not economically viable for use on small farms. To provide the ability to mechanically harvest edamame and bush beans, a proto type of a bean picker was designed and constructed specifically for small farmers. The design is semi-compact, relatively easy to build for someone with fabrication experience and easy to operate. The investment costs were minimal (far below $20,000) and many of the parts were machined by hand, but if the design is picked up by a commercial fabricator or replicated by other farmers, design

modifications could allow use of commercially available parts, eliminating the need for custom machining.

Parameters for measuring the success of the machine include changes in yield due to increased harvest capacity and decreases in amount of time spent on harvest. Hand harvested edamame requires about one hour to obtain 8 pounds. The edamame harvester picked 8 pounds of edamame pods in 2 minutes. Mechanical damage to the pods was less than 5%. The harvester is capable of picking an acre of edamame in approximately 5 hours compared to 871 man hours for hand harvesting one acre of edamame beans. It pulled approximately 95% of the pods off the plants.

Documentation of yields, performance, quality
While not able to document yield since harvest did not occur, in order to meet this goal, research was conducted to obtain information about yield of edamame. An average yield is .25 lb. of pods per plant. If growing larger quantities, farmers typically average 2.5 - 3.0 tons of edamame pods per acre. The yield of shelled edamame is about half the volume of edamame in the pod. Although the crop for this project was not able to be harvested, in terms of yield, it was anticipated to have a yield of ¼ lb. of pods per plant, which would equate to 2.5-3.0 tons of edamame pods per acre. The yield of shelled edamame is about half that. The ¼ acre that was planted for this study was projected to yield about 1,500 lbs. or approximately 30 bushels of edamame. Typically, a bushel of edamame contains 28-30 lbs.

Consideration of herbicides, insecticides, and similar production factors
Research was conducted to meet the goal of understanding what herbicides and insecticides were effective and safe for use on edamame. Two herbicides recently labeled for use on edamame, imazamox (Raptor, BASF) and fomesafen (Reflex, Syngenta), both used in soybean for years, were recently registered by the Environmental Protection Agency (EPA) for use on edamame

Methods of processing and market appeal
Through research, the goal of learning the best methods of processing was accomplished. However, if the edamame is processed, it must be done quickly, according to all knowledgeable sources. Two sources mentioned it taking 4-6 hours to harvest, clean, shell, blanch and prepare the beans for packaging. Fresh, locally grown edamame is very appealing to consumers, but it is difficult to find, since over 90% of the product is imported from China and Japan.

Evaluation of fresh vs. frozen processing and shelled and in-shell options
Edamame can be marketed as a fresh vegetable or as a frozen food. After harvest, the edamame can be sold to a processor for freezing or it can be shelled and sold to the local market. Frozen edamame can be found in large grocery chains and in smaller grocery stores as well. Most stores offer a variety of package sizes, from single serving size to bulk servings.

As for the shelled vs. in-shell options, shelled edamame has become popular to add to salads soups, pasta dishes, stir-fries, or casseroles, or can be served as a side dish like peas. In-shell edamame is a staple at Japanese sushi restaurants or, after boiling and salting, consumers can eat the beans directly from the whole pod (pods are not edible) as a healthy protein snack.

Protocol for blanching and freezing product to maintain optimum flavor
Blanching edamame before freezing stops the plant's natural enzymes from continuing the ripening process. If edamame is placed in the freezer without blanching, it will spoil faster. To freeze fresh edamame in the pod, the sorted pods should be cleaned by spraying water. Next, blanch by bringing a pot of water to a boil. Add edamame in the pod to the pot, bring back to a boil, and boil for about 2 minutes. Drain. Rinse with cold running water to cool or place in ice water. The pods are sorted again to remove all unqualified pods. They should then be taken through a quick freezer and frozen. The pods freeze without forming any large ice particles and thus suffer only minimal damage to the bean tissue. The frozen pods are stored in freezers until shipped in refrigerated containers. The beans can also be shelled from the pods and sold or they can be frozen, packed, and sold.

Packaging considerations based on entry into the market i.e. bulk for foodservice
There are a variety of size and packaging options on the market for edamame. Packaging was typically a plastic bag containing the frozen product, but another type of packaging, a small cardboard box, provided a single serving of the product, with a venting capability in the box. The larger wholesale stores offered the product in separate plastic packages, contained in a cardboard box, so consumers could open one package at a time.

Collect consumer feedback on the processing techniques and desirability
Consumers are strong supporters of locally grown fresh food, and edamame is no exception. Research showed that consumers are willing to pay more for local produce, including edamame. In addition, Edamame is high in protein, low in fat, and has nutritional value to consumers looking for new and unique vegetables. Edamame is often boiled or steamed as a snack or added to salads or Asian cuisine.

Economic evaluation compared to imported to the increased value gained from local
The demand for edamame in the U.S., especially organically grown edamame is increasing in health food and Asian markets across the country. Ohio growers may want to take advantage of the opportunity to grow a specialty crop that can achieve a premium price. Marketed fresh at farmers' markets, edamame bunches (whole plants with stems and pods) can go for more than $4.00 per pound. Fresh edamame pods (picked off the stems) sold wholesale to grocery stores bring the same price. Food trend experts and farmers say edamame remains a niche product but they see potential for growth for U.S. grown edamame if food companies can implement an efficient processing system for a crop that must be harvested and packaged quickly.

Beneficiaries
The target audience for this initiative was broad. First and foremost, specialty crop producers interested in adding new crops to their current offerings were very interested and provided information and remained engaged in this project throughout, despite the weather. Secondly, consumers and buyers (retailers, wholesalers, foodservice venues, and more) could be provided a new locally produced product. The interest in local is unmatched and consumers are validating the desire with a willingness to pay a premium for local produce. Institutional buyers are also capitalizing on the inclusion of local as a marketing advantage.
A Presentation entitled "Growing Agricultural Businesses through Innovative Techniques" held on December 4, 2014 was attended by 40 agricultural professionals, including educators, growers, greenhouse supervisors, hoop house managers, and vegetable consultants. In addition, CIFT Agriculture breakfasts, held

monthly throughout the year presented information about this project. The breakfasts average 25-30 individuals each month, resulting in an additional 250-300 growers and agricultural professionals who were who were presented with information about and results of this project. This information provided a potential economic impact by introducing the concept of growing edamame as a profitable crop in Ohio to over 300 agriculture professionals. Information was sent to more than 150 growers defining the project and encouraging connectivity based on interest in the crop. Several regional green bean growers expressed a desire to compare edamame to the resources and equipment needed for green bean production. Bon Appetit Management Company, managing significant institutional cafeterias, inquired as to the potential to source local edamame and also communicated the interest to growers while directing them to this project for further clarification on production.

Lessons Learned

The main challenge for this project was a familiar one; the weather. Avoidance of limiting factors will increase probably of success, however it is impossible to predict and limit the weather conditions. In order to overcome the weather issues, outreach was done to industry experts, growers, buyers, consumers, and participants at farmers markets to discuss various aspects of edamame, including the challenges of growing it, buying and selling it, and the market appeal for this product.

At the start of the project, harvesting and processing were anticipated obstacles. These continue to be areas in which a grower must be prepared to address. The window of opportunity for harvest is very small and strategic planning in terms of equipment availability and staggering of the crop will be critical in order to produce on a larger scale. Labor is certainly a limiting factor although accessing harvesting equipment can provide some relief to the harvest aspects. The existence of a facility to IQF produce in the region is another benefit to growers considering this crop. Again, labor to process and the cost associated can be limiting without optimum market prices.

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Additional Information

The most valuable aspect of this project was the inclusion of a grower conducting a test plot for monitoring. Although it didn't ultimately result in a harvest for processing, the insights from a production standpoint could be compared to that of the available documentation. It is unfortunate that the processing component couldn't be achieved since that is a substantial hurdle for the crop. Efforts to obtain fresh edamame from a wholesaler were not successful as the entire product carried was already frozen.

Project Title: CIFT -- Evaluation of Dehydration of Specialty Crops

Project Summary

The following information describes the results of the project coordinated by CIFT to review the processes and potential for drying (including freeze-drying) and/or dehydration of various specialty crops and also for packaging them with other ingredients. The approach applied helped to gain

insight into commercial scale dehydration, and translate that insight into valuable information about a viable crop preservation option for Ohio growers. A comprehensive evaluation of this process incorporated the comparison of dehydration to freeze-dried, use and evaluation of equipment, test runs of crops, procedure documentation, consumer evaluation, economic analysis, and information sharing sessions to communicate the value of such a technique.

The interest in and opportunities for dehydration are expanding in 2016 for a number of reasons. Dehydration is viewed not only as a food preservation method, but also as a way to increase food safety and more recently, as a means to lessen food waste, especially for fruit and vegetables deemed imperfect or "ugly", that otherwise might end up in a landfill, composted, or as livestock feed. Dehydrated specialty crops like broccoli, brussels sprout and parsnip chips are lining the health food store shelves, and dehydrated fruits and vegetables have become a hot new food trend for 2016.

This project addresses the potential for expanding the crop dehydration application so as to capitalize on the market appeal of this process as it relates to preservation, food safety and decreasing food waste. The overarching goal was to provide specialty crop growers with a viable option for processing their crops by integrating dehydration techniques for both Grade A and Grade B products that will serve as a favorable method for increased food preservation, safety and health, as well as increased profit margins for the grower, along with the reduction of food waste.

This project provided growers with the technical information necessary to make business decisions when selecting food preservation techniques. CIFT began implementing a blanching/freezing operation wherein a product can be processed and frozen for later use in pies, casseroles, smoothies, etc. with little attention to appearance. The challenge with this form of food preservation is that the cost to process, store, and transport can be prohibitive. Inclusion of dehydration as an option for preservation eliminates some of these cost factors and can provide a ready to eat snack for consumers desiring a "healthy" preservation option (no chemicals) with local appeal. The economic advantage is also in the ability to leverage this process for Grade B products, which helps with waste of food reduction, as well as in capitalizing on the "natural preservative" aspect, which is of extreme interest in the limited infrastructure and food handling capabilities in today's global market.

Project Approach

Following please find the project activities/goals that were accomplished as outlined in the proposal:

Activity/Goal	Performance measure	Benchmark	Target	Final Results
Explore processing	Compare dehydration to freeze-dry	Current documentation on the methods	Identify which is most applicable	Compared dehydration to freeze dried techniques
Evaluate equipment needs	Research at least 3 methods	Information available on small scale-to commercial	Increased awareness of best practices	3 dehydrators, scale, and moisture analyzer evaluated

Create procedure based on product	Select 7 different crops for evaluation	Have a listing of typical items	Confirm items appropriate for dehydration	Created by CIFT safety expert and included in report
Conduct test runs	Use same crops selected as trail batches	Comparative product from the market	Samples of local items using this technique	Test Runs and data included in report
Consumer evaluation	Share samples with consumers	Purchasing preferences of consumers	Identify crops with greatest consumer appeal	Shared product with Toledo Kitchens participants and obtained feedback
Evaluate economics	Survey companies and consumers	Know what is currently done with this approach	Create a pilot effort to process for growers	Researched economics of dehydration and provided data in report
Share results	Conduct 2 information sessions	Compare to freezing	Increased opportunities for local growers	Provided several sessions and tours
Outreach	Information sharing	Incorporate existing tools	Post on website, social media outlets, documents for referral	Provided information through social media, reaching out to growers
Market Research	Review current products/pricing	Details from industry	Identify crops with most potential for Ohio	Conducted market research on what is available and pricing

Goals and Outcomes Achieved

Dehydration of food offers a number of advantages for growers. The process, which removes the moisture from the food, eliminates bacteria, yeast and mold from growing and causing spoilage. Because drying removes moisture, the food becomes smaller and lighter in weight, thereby reducing costs of transporting the product. The goal of this project was to evaluate the process, including equipment, procedures, packaging, and the market, and disseminate the information to growers through outreach. The grower is provided with another avenue for processing to maximize production and profit.

Through collaboration with CIFT's Northwest Ohio Cooperative Kitchen (NOCK), CIFT was able to determine how to take this food preservation method from small scale to a commercial level, specifically for Ohio crops. Nine focus areas/goals were applied to the initiative. Activities and outcomes achieved are noted below for each:

A. Explore Processing

This focus area was comparing the dehydration process to freeze-drying of food. A variety of herbs were selected to explore the processes. Herbs have always been a very popular food to dehydrate and recently, some creative chefs have discovered a new way to incorporate herbs into their creations, called herb dust. Herb dust is made by dehydrating fresh herbs and then grinding them with a spice or coffee grinder. Herbs are often offered at CSAs, and if customers aren't using their allocation right away, they can dehydrate them while they are still fresh to create their own dried herbs.

A test batch of two classifications of herbs was explored. The first classification, called hard herbs, consisted of rosemary, thyme, oregano, sage, and savory. Hard herbs are typically used in recipes that require 30 minutes or more of cooking time. The second classification, called soft herbs, includes parsley, dill, basil, chives, and mint. These soft herbs are typically used raw for garnishes, and require less than 30 minutes of cooking time.

Prior to dehydrating the herbs, washing occurred. Certain vegetables and fruits require blanching prior to dehydration. Blanching is a pre-processing step where the produce (or herbs) are subjected to high temperature, generally either in the form of hot water or steam. Blanching causes inactivation of enzymes responsible for biochemical changes such as browning, chlorophyll, lycopene, and carotene degradation, off-flavor development, reduction in microbial load and escape of entrapped gas in the intracellular spaces.

Freeze-Dry-Hard/Soft herbs

For these processes, three kitchens in the Toledo area agreed to test the processed herbs (using the freeze-dried and dehydration methods), in the meals they prepared. The kitchens in turn shared feedback concerning quality, flavor, and benefits as well as the disadvantages of both the frozen and the dehydrated herbs.

Both the hard and soft herbs, after being freeze dried, retained their color, and minimal flavor loss was experienced. However, the texture of the herbs, both soft and hard, turned limp, so they could not be used to garnish food. It was determined that the best way to freeze the herbs was to wash, dry, and then chop the herbs and place in ice cube containers with oil or water. Once frozen, the ice cubes were placed in a Ziploc bag, any air was removed, and the bags were laid flat. These were then provided to the kitchens. Based on feedback, it was discovered that when thawing the herbs, it helped to extract the flavor if some oil was infused prior to adding the herbs to the recipe. In addition, thawed herbs increased in flavor when adding them to the end of the cooking time of the dish. Other information included:

- Had to use twice as much of the soft herb to get flavor
- Would be best to use during non-growing season of fresh herbs
- Not practical for making tea

Dehydrate - Hard/Soft herbs

In dehydrating both the hard and soft herbs, it was found that with this process there was some loss of color, but minimal flavor loss. With the dehydration process, the texture of all of the herbs turned crisp or brittle, which is a positive indicator that all moisture has been removed. The kitchens were able to use some of the dehydrated herbs as garnish at the end of the cooking process for certain soups, salads, and pizza.

Drying Using a Dehydrator

Two important factors are necessary for dehydration to take place – heat and air circulation. The heat pulls the moisture from the food, and air circulation moves the moisture so that it can evaporate. Therefore, where the dehydrator is placed is an important factor. Using it in a very damp basement, for example, will prevent proper drying.

When drying using a dehydrator, it is important to distribute the food on trays in a single layer. Different foods can be dried at the same time, but try to choose foods that will dry in about the same amount of time, (dry similarly sized pieces together). Onions, peppers, and other strong foods tend to flavor other foods, so they should be dried separately. Moisture must be removed from the food as quickly as possible at a temperature that does not seriously impair the flavor, texture, or color of the food. If the temperature is too low at the beginning, the food may spoil before it dries. If the temperature is too high, the surface may harden so that the interior dries much more slowly. Start the dryer at 140° to 150°F, and then after 2 to 3 three hours, lower the dryer temperature to 130°F to 140°F. Adequate air flow can reduce drying times. Monitor the drying process. If necessary, rotate the trays to ensure even drying. Grated, shredded, or finely cut foods may need to be stirred during the process.

Drying Time

Many factors affect drying time, including type of food, size and moisture content of the food pieces, pretreatment method, dryer type, dryer temperature, relative humidity of the air, and amount of air movement in the dryer and in the surroundings. Generally, drying times will be 6 to 36 hours for fruit and 3 to 16 hours for vegetables, which take less time due to their lower sugar contents. Dehydrator machines will include general guidelines for drying times for various foods. Vegetables are sufficiently dry when they are brittle or leathery. Leathery vegetables will be pliable and spring back if folded. Brittle vegetables such as corn and peas will shatter. Fruits are sufficiently dry when they are pliable and leather-like and have no pockets of moisture. Herbs are sufficiently dry when brittle. Their leaves will shatter when rubbed together. When in doubt about the dryness of a food, continue to dry it. Foods dry more quickly toward the end of the drying period, so need to be checked frequently, and should not be left them in the dryer after they are done. Leaving them in will reduce their quality. To ensure optimum levels, a moisture analyzer was purchased and will depict the exact level of moisture existing within the product. Product packaged for commercial purposes will benefit from longer shelf life perspective.

Packaging

Good packaging and storage techniques after dehydrating are crucial. Packaging protects the dried food from oxygen, moisture (gain or loss), light, microorganisms, and pests. After it has been determined that the foods are thoroughly dry and cool, they should be packed immediately for storage.

Choosing Containers

The ideal container for a dried food is:

- Clean and sanitary
- Nontoxic
- Lightweight
- Easily disposable or recyclable
- Moisture resistant
- Airtight
- Protective against light
- Easily opened and closed
- Impermeable to gases and odors
- Durable
- Low-cost

Unfortunately no single food container has all these characteristics. Determinants for which containers to use include the type of dried food, storage conditions, and storage time. A good method for storing dried food is to place sealed plastic bags inside a larger glass or metal container with a tight-fitting lid. This two-step packaging has the advantages of being relatively easy, allowing more food to be stored in one container, and protecting against insects and other pests.

For this effort, the following was used:

- **Mason Jars (canning) air tight lids - 8 ounce** (apples/potatoes/sweet potatoes/onions/green beans) While appearance is appealing, since the packaging is non-flexible there is an issue with limiting the amount of product placed in the jar. In terms of storage, jars can be stackable, and any moisture would be visible.

- **Zip Lock Vacuum Bags (quart/gallon) (hand Pump)** - provides longer shelf-life, retains better color, texture, and maximizes the amount of product placed in the bag.

- **Zip Locked Bags (quart/gallon)** - Zip Lock- "burped" the air out, which made the container equivalent to the vacuum bag.

All three containers tested provided good results. In terms of which option is the most cost efficient, this is still under review. Following are pictures of the containers with dehydrated herbs:

Dehydrated Herbs in Mason Jars

Dehydrated Herbs in Zip Locked Bags –air "burped out"

Dehydrated Herbs in Zip Locked Bags – Vacuumed with air pump

Storage

The length of time to store dried food depends on:

- The type of food
- Factors related to the drying process (pretreatment and final level of moisture)
- Packaging of the dried food
- The storage area

An ideal storage area for dried food is cool, dark, and dry. The cooler the storage area, the longer the shelf life will be. Dark areas are ideal because any light fades fruit and vegetables and decreases their vitamin A and C contents. Metal containers have the advantage of keeping their contents in darkness. Glass or plastic containers can be covered with a cardboard box, a barrel, or black plastic to keep light out. During storage at room temperature, the most common type of spoilage is mold growth. Molds can grow in foods that are not completely dry and in foods that

absorb water when they are packaged or stored in moist conditions. Dried food will probably not absorb enough water to allow bacterial or yeast spoilage. One typical change that occurs during storage is "Maillard browning," which involves complex chemical reactions between the food's sugars and proteins. Other chemical changes that may take place during storage include loss of vitamin C or other nutrients, general discoloration, changes in food structure leading to an inability of the dried food to fully rehydrate, and toughness in the rehydrated cooked product. It is important to note that dehydration slows deterioration of food, but does not halt the process completely. A Colorado State University fact sheet on drying vegetables recommends that dehydrated foods be used within one year.

B. Evaluate Equipment Needs

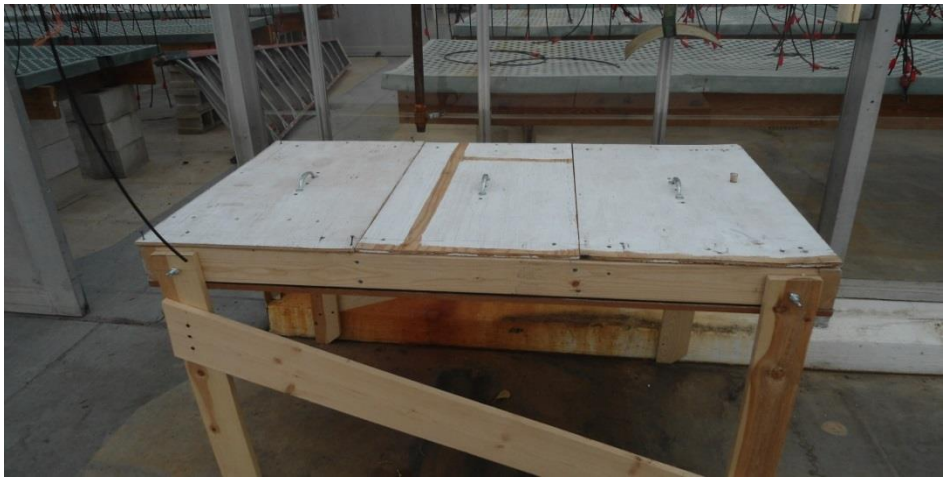
For this project, five methods of dehydration were evaluated, including: a convention oven/steamer combination, air rack drying, a home dehydrator, a small commercial dehydrator (5 trays), and a larger commercial dehydrator (20 trays). It was determined in the beginning of the project that the convention oven/steam combination was not adequate to use for dehydrating the herbs. The air racking drying process was somewhat successful; however, the drying process took a long time (7-10 days, depending on the food), and it was determined that, with the issues pertaining to time and quantity to get to the end product, this option was not feasible for commercial use. The home dehydrator provided good results - this method kept the herbs almost to their natural state, fresh, in color, aroma and appearance. However, only a very small amount of herbs could be dehydrated at a time, and took 24 hours. Thus this method was also deemed unfeasible for commercial use. The small commercial dehydrator was more successful – dehydrating only took as little as five hours but up to 25 hours for some of the herbs. The end results were excellent specific to color, texture, and flavor of the final product. Finally, the commercial dehydrator was very successful, with the only issue being its inability to properly record the moisture content of the end products, hence the need for the moisture analyzer. All herbs tested in the large commercial dehydrator took either 5 or 6 hours. Commercial dehydration devices are easily obtainable in different sizes, versatility, & quality, widely used in home-businesses and households by using heat source such as solar, electric and biofuel. Price ranged from $30 (households appliances) to $3000+, with notable brands like Excalibur, Nesco and Presto.

Buying a Dehydrator

Before purchasing a food dehydrator, it is recommended that it have the following features:

- Instruction manual.
- Thermostatically controlled temperature dial with settings between 130° and 150°F. (For example, to dry meat jerky, the dehydrator must be capable of maintaining a temperature of 145°F.)
- Fan or blower to distribute warm air evenly.
- Shelves made of stainless steel or food-grade plastic. (Galvanized screening is not food-safe.)
- Easy loading and unloading features.
- Outside cabinets made of hard plastic, aluminum, or steel. The highest quality dehydrator has double-wall construction with insulating material sandwiched between the walls to reduce the amount of heat lost during use.
- Enclosed heating element.
- Appropriate number of trays for use. Most food dryers come with 4 to 10 food trays.
- Source of replacement parts.

For this project, a homemade air drying rack, Excalibur 5-tray stainless steel dehydrator (small commercial), which cost $399.95, and a D-20 Digital Touch Food Dehydrator 20 tray commercial stainless steel machine (large commercial), with a price tag of $5655 were used. Comparing these three pieces of equipment, the D-20 was the quickest and most efficient. The D-20 also allowed for quicker drying time of more product, since it was equipped with a four fan system. In addition, a certified scale was utilized to weigh the product before and after dehydration. The cost of the scale was $1236.00. Following are pictures of the equipment used:



Homemade Air Drying Rack

Home Dehydrator

Small Commercial Dehydrator (5 racks)

Large Commercial Dehydrator (20 racks)

Certified scale used to weigh before and after dehydration

C. Create procedure based on Product

The CIFT safety expert looked at the processes followed for freeze drying and dehydration of vegetables and fruits and designed good manufacturing practices and procedures around those processes. Several forms were generated as well for tracking and recording of information. A sample form can be found in the attachment section of this report. Procedures will vary based on the facility in which processing is taking place.

D. Conduct Test Runs

DEHYDRATION PROJECT FOR HERBS IN LARGE COMMERCIAL DEHYDRATOR						
DATE	PRODUCT	JAR	Vacuum Seal	TIME	WEIGHT BEFORE DEHYDRATION	WEIGHT AFTER DEHYDRATION
7/20/2015	Lemon Balm	1	1	6 hour/med	3.0oz	1.5oz
7/20/2015	Horehound	2	3	6 hour/med	7.0oz	5.45 oz.
7/20/2015	Summer Savory	4	6	6 hour/med	35.7oz	24.0 oz.
8/24/2015	Italian Basil	1	2	6 hour/med	2lbs	19.0 oz.

9/3/2015	Thyme	1	1	5hour/high	6.0oz	1.5oz
9/3/2015	Stevia	2	4	5hour/high	1.5lbs	6oz
9/3/2015	Rosemary	1	2	5hour/high	7.0oz	3.0oz
9/4/2014	Peppermint	1	3	5hour/high	12.0oz	3.0oz
9/4/2014	Spearmint	1	2	5hour/high	8.0oz	1.50z
9/4/2014	Oregano	4	5	5hour/high	1.5lbs	8.5oz
9/4/2014	Queen Siam Basil	2	4	5hour/high	3lb	15.0oz
9/6/2015	Dill	2	3	5hour/high	52.0oz	13.0oz
9/11/2015	Cinnamon Basil	2	3	6hours/med	4lb/2lbs	8.5oz
9/11/2015	Spearmint	1	1	6hours/med	5oz	2.5oz
9/11/2015	Peppermint		2	6hours/med	9.0oz	3.0oz
9/22/2015	Dill	1	1	9hours/high	23.5oz	10.5oz
9/23/2015	Savory	4	2	6hours/med		7.5oz
9/23/2015	Peppermint	1	1	6hours/med		2.0oz
10/5/2015	Chocolate Mint		1	6hours/med	1.7oz	0.5oz
10/5/2015	Peppermint		1	6hours/med	2.10z	0.5oz
10/5/2015	Pineapple Sage		1	6hours/med	9.0oz	1.0oz
10/5/2015	Golden Sage		1	6hours/med	4.0oz	0.5oz
10/12/2015	Purple Sage		1	6hours/med	1.5oz	.5oz
10/12/2015	Peppermint		1	6hours/med	4.0oz	.5oz
10/12/2015	Pineapple Mint	1	2	6hours/med	7.0oz	3.0oz
10/12/2015	Dill		1	6hours/med	6.0oz	.5oz
10/12/2015	Orange Mint		1	6hours/med	3.0oz	.5oz

DEHYDRATION PROJECT FOR HERBS IN SMALL COMMERCIAL DEHYDRATOR						
DATE	**PRODUCT**	**FROZEN**	**FRESH**	**TIME**	**WEIGHT BEFORE DEHYDRATION**	**WEIGHT AFTER DEHYDRATION**
4/15/2015	Curly Parsley	X		5 hours	5 oz.	3.10 oz.

4/16/2015	Curly Parsley	X		5 hours	8 oz.	5.45 oz.
4/17/2015	Curly Parsley	X		4 hours	2.5 oz.	1.7 oz.
4/17/2015	Curly Parsley	X		6 hours	3.5 oz.	2.3 oz.
4/17/2015	Italian Parsley	X				8.0 oz.
4/23/2015	Green Chives	X		20 hours	8 lbs.	17 oz. dried
4/28/2015	Garlic Chives	X		25 hrs.	3.8oz/3.9oz/4oz/4oz/4.2oz	
4/30/2015	Garlic Chives		x	12 hrs.	2.3oz/2.60z	
5/15/2015	Oregano		x	12 hrs.	2.6oz/2.1oz/3.5oz/3.0oz/1.3oz	

DEHYDRATION USING HOME DEHYDRATOR						
DATE	**PRODUCT**	**FROZEN**	**FRESH**	**TIME**	**WEIGHT BEFORE DEHYDRATION**	**WEIGHT AFTER DEHYDRATION**
1/15/2015	Rosemary		x	24 hrs.		1.2 oz.
1/15/2015	Thyme		x	24 hrs.		2.5oz
1/15/2015	Oregano		x	24 hrs.		.8oz
1/15/2015	Pineapple Mint		x			.6oz
1/15/2015	Italian Parsley		x			.4oz
1/15/2015	Sage		x			1.4oz

DEHYDRATION OF HERBS						

USING AIR RACK DRYING						
DATE	PRODUCT	FROZEN	FRESH	TIME	WEIGHT BEFORE DEHYDRATION	WEIGHT AFTER DEHYDRATION
1/15/2015	Rosemary		x	48 hrs.		3.8oz
1/15/2015	Dill		x	48 hrs.		1.5oz
1/15/2015	Thyme		x	48 hrs.		1.7oz
1/15/2015	Sage		x	48 hrs.		2.1oz
1/15/2015	Oregano		x	48 hrs.		2.0oz
1/15/2015	Garlic Chive		x	48 hrs.		4.0oz
1/15/2015	Pineapple Mint		x	48 hrs.		1.4oz
1/15/2015	Italian Parsley		x	48 hrs.		2oz
1/15/2015	Curly Parsley		x	48 hrs.		2.1oz
4/23/2015	Garlic Chive		x	2 weeks		1.0oz
4/23/2015	Oregano	X		2 weeks		.8 oz.
4/23/2015	Garlic Chive	X		2 weeks		1.2 oz.
4/23/2015	Italian Parsley	X		2 weeks		.7oz/.5oz/.9oz

PRODUCT	TEMP. TIME IN HOT WATER BATH	COLD BATH	FAN SPEED	TEMPERATURE	DEHYDRATING TIME	PACKAGING
Sliced Sweet Potatoes	3 min. to achieve boiling once potato is in water and then boil additional 5 minutes	15 minutes	High	125 degrees	10 hours	Sealed in mason jars

Sliced White potatoes	3 min. to achieve boiling once potato is in water and then boil additional 5 minutes	15 minutes	High	125 degrees	8 hours	Sealed in mason jars

E. Consumer Evaluation

The dried fruit and vegetable snack production industry is growing and manufacturers are benefitting not only from improving economic conditions, but also, from shifting consumer preferences for the healthier dehydrated products, along with more disposable income that allows them to pay the higher prices that dried produce demands. Sales of snacks with dried fruit and vegetables climbed 1.7% annually over the last five years and are predicted to continue. And the consumption of dehydrated foods, once considered the campers and survivors food, isn't just for camping anymore. Dehydrated foods are niche products of particular interest to consumers desiring locally produced foods. The demand for local, nutritious dried fruits and vegetable is high, in part because consumers are interested in eating local, summer time foods all year long. Dried fruits and vegetables take up less space, can be safely stored at room temperature, and have a longer shelf life compared to fresh. They can be eaten in the dried state or rehydrated. In addition, dehydration is a great way to lock in nutrients and preserve a variety of foods, and this health-driven idea has been catching on among consumers for the past several years. Finally, with the Community Supported Agriculture (CSA) trend exploding, consumers are looking for ways to enjoy their local fruits, vegetables and meat without wasting any of their allotted portions, and dehydration is a way to do it.

Mom's Reported Uses of Different Forms of Fruits & Vegetables[16]

How do you use frozen and canned fruits and vegetables? (Please check all that apply.)

	% Respondents				
	FRUITS			VEGETABLES	
	Frozen	Canned	Dried	Frozen	Canned
Snacks	39%	64%	79%		
Dessert	54%	46%			
Smoothies/ Beverages	69%	16%			
Fruit Salads	29%	37%			
As is	33%	67%			
Baking			38%		
Trail mix			39%		
On cereal			31%		
In salads			30%	15%	16%
Side dish				89%	89%
Casseroles				52%	51%
Soups/stews				54%	49%
Stir-fry				49%	20%
Add to sauces				18%	13%
Other	4%	4%	1%	2%	1%
Don't use	1%	0%	5%	0%	0%
	(n=390)	(n=687)	(n=399)	(n=854)	(n=814)

Empty boxes indicate the category was not presented to the respondent.

Rehydrating Dried Foods

Product	Water to Add to 1 Cup Dried Food (Cups)	Minimum Soaking Time (Hours)
Fruits*		
Apples	1 1/2	1/2
Pears	1 3/4	1 1/4
Peaches	2	1 1/4
Vegetables**		
Asparagus	2 1/4	1 1/2
Beans, lima	2 1/2	1 1/2
Beans, green snap	2 1/2	1
Beets	2 3/4	1 1/2
Carrots	2 1/4	1
Cabbage	3	1
Corn	2 1/4	1/2
Okra	3	1/2
Onions	2	3/4
Peas	2 1/2	1/2
Pumpkin	3	1
Squash	1 3/4	1
Spinach	1	1/2
Sweet Potatoes	1 1/2	1/2
Turnip Greens and other greens	1	3/4

* Fruits – Water is at room temperature.
** Vegetables – Boiling water used.

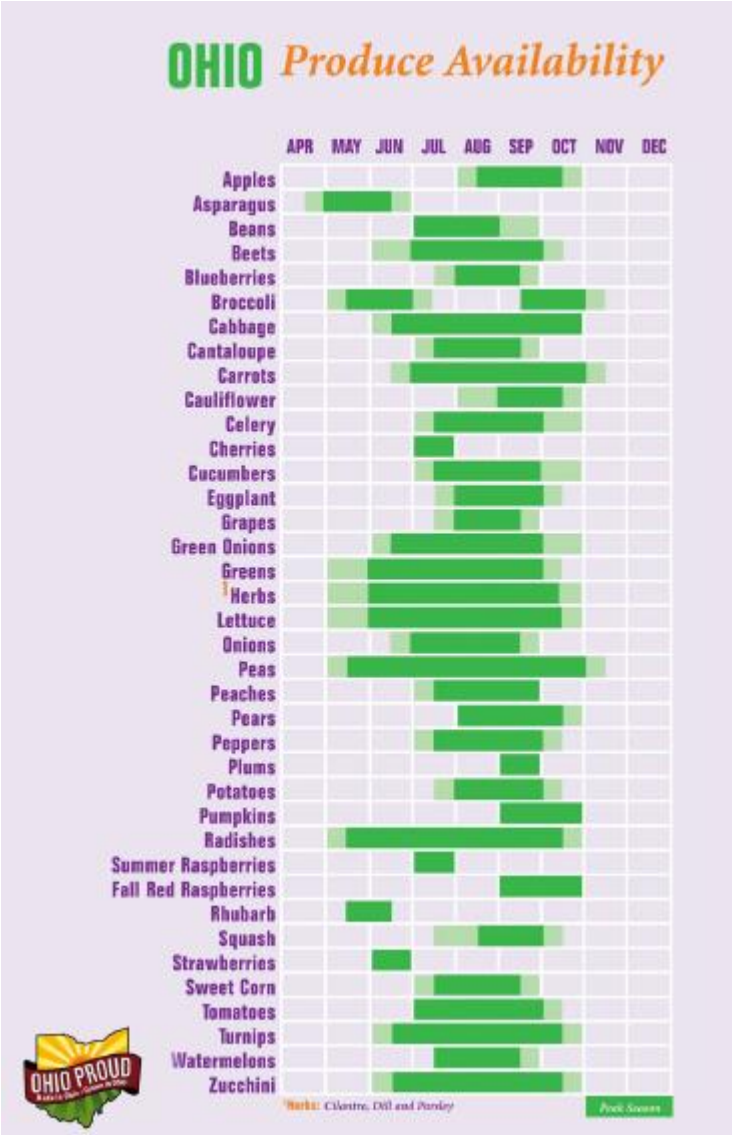
F. Evaluate Economics

Agriculture is Ohio's number one industry contributing jobs for one in seven Ohioans and more than $107 billion to the state's economy. The food and agriculture cluster is the largest sector of Ohio's economy (farms, processing, wholesaling, retailing, & food service).

Ohio is an ideal place for locally grown dehydrated produce for a number of reasons:

- Ohio has a unique proximity of metropolitan and micropolitan areas, linking rural and urban consumers, growers and communities.
- Producers in Ohio grow more than 200 different crops that include an increasing variety of fruits, vegetables, and herbs, and more. Ohio ranks in the top ten states for direct-to-consumer marketing.
- Ohio is among the top five states for food production of bakery, dairy, snacks, spices, maple syrup and other products, all with potential dehydration possibilities.

The current popularity of dehydration as a healthy, preservation method among consumers, as well as a way to lessen food waste, points to a huge potential for leveraging this methodology in Ohio. Further, Ohio is able to grow some of the most ideal crops for dehydration, including both fruits and vegetables. The following chart depicts the types of produce grown in Ohio:



Great for concentrating flavor in fruits and vegetables, dehydrators have never been more popular with chefs. Here, a look at how this trend is playing out on plates around the country.

1. Grapefruit Pieces
A tart accent for granola at The Hive in Bentonville, AR.

2. Carrot Jerky
Marinated in tamarind, soy and chile as a bar snack at Oak in Dallas.

3. Zucchini Strips
Thinly sliced and naturally sweet in salads at Bar Tartine in San Francisco.

4. Ginger Pulp
Dried as a cocktail garnish at Root & Bone in New York City.

G. Share Results

This goal was accomplished by conducting information sessions:

a. Results shared with Ohio Produce Growers and Marketing Association (200 attendees)
b. Several tours of the dehydrator and finished product to growers at NOCK facility reaching approximately 75 participants.
c. Growing Agricultural Businesses Through Innovative Techniques Workshop (1 meeting – flyer attached) and the December 2014 session had 50 attendees
   Unique Agriculture Products to Help Your Business Grow Meetings (4 meetings – flyer attached)

H. Outreach

The entire database of growers received email correspondence communicating the activities and results of this project. Estimating an open rate of 50%, it would be safe to anticipate at least a 35% increase in awareness of this technique. Additionally, growers who toured the facility became familiar with the process potential and all of the growers providing product for the blanching/freezing operation became aware of this alternative approach. Prior to this project, only a non-profit organization inquired about dehydration.

All attendees of meetings were asked to indicate prior knowledge of commercial dehydration and the potential for integration into their operation. In each session, only one or two indicated prior knowledge. An electronic survey was sent to growers defining the available resources and recommending direct communication for additional insights.

This goal was accomplished by sharing information electronically and in person:

a. Dehydrated product provided to three local kitchens for use in their meals and feedback obtained from personnel and consumers.
b. The project was promoted at every monthly CIFT Ag breakfast event in 2015 and 2016 (Averaging 30 per session)
c. The project was promoted to 120 growers via CIFT Newsletter
d. Tweeted about project through CIFT Twitter Account on many occasions
e. There have been entrepreneurs interested in dehydrating items either for spices or soup mixes. One particular contact operates a restaurant and they make dried hot pepper flakes.

I.Market Research

When dried, most produce loses from 60 percent to more than 90 percent of its weight compared to when fresh. This must be considered when comparing prices between dried and fresh food. For example, tomatoes typically lose about 95% of their mass when dried. If dehydrated tomatoes are on sale fresh for $2.00 a pound, it is cheaper to purchase the sun-dried tomatoes for $12 a pound.

Dried fruits are generally more common in most grocery stores than dried vegetables. In terms of price, one dried vegetable that is consistently cheaper per serving than fresh is instant potato flakes. Among dried fruits there are a few that are consistently lower in price compared to fresh. Below are some of the Ohio grown fruits and vegetables that can be dehydrated:

Ohio grown vegetables to dehydrate:

- Asparagus
- beans of all kinds (must be fully cooked first)
- beets
- bell peppers
- broccoli
- cabbage
- carrots
- celery
- cauliflower
- corn
- cucumber
- eggplant
- herbs
- hot peppers
- greens
- onions (larger chunks -- onion flakes are cheap)
- peas
- potatoes - diced or cubed only
- radishes
- squash (both summer and winter)
- sugar snap peas
- sweet potatoes and yams
- tomatoes, sauce, tomato paste (make fruit leather)
- turnips

Ohio grown fruits to dehydrate:

- apples
- blueberries
- cantaloupe
- cherries
- grapes
- peaches (puree and make a fruit leather)
- pears (puree and make a fruit leather)
- raspberries
- rhubarb
- strawberries
- watermelon

Beneficiaries
The target audience for this initiative was Ohio growers and the agricultural industry, so as to demonstrate how dehydration could benefit specialty crop growers in Ohio. In addition to the growers, the end users of the dehydrated products, including restaurants, kitchens, buyers (retailers, wholesalers, foodservice venues, and more) and consumers, will benefit from the information, by understanding more about the methodology related to this form of food preservation. Dehydration can enhance food safety, provide a natural means of food preservation as opposed to chemical and other unnatural methods to preserve food, and lessen food waste.

A Presentation entitled "Growing Agricultural Businesses through Innovative Techniques" held on December 4, 2014 was attended by 40 agricultural professionals, including educators, growers, greenhouse supervisors, hoop house managers, and vegetable consultants. In addition, CIFT Agriculture breakfasts, held monthly throughout the year presented information about this project. The breakfasts average 25-30 individuals each month, resulting in an additional 250-300 growers and agricultural professionals who were provided with information about and results from Evaluation of Dehydration of Specialty Crops project. This information provided a potential economic impact by introducing the concept of using the dehydration technique for B grade produce as well as extending the produce season using this technology to over 300 agriculture professionals in Ohio. Through participation in the Ohio Produce Growers and Marketers Association trade show, upwards of 400 additional growers were presented information on this processing technique.

Lessons Learned
There were several important lessons learned to share with those growers who are considering dehydration for their crops. First of all, the moisture level of the final product is critical and needs to be measured, per safety protocol. While the large commercial dehydrator had this information incorporated into its process so as to obtain the appropriate moisture level for each food, there was no actual report that provided this data point, as proof of the moisture level of the final dehydrated product. That data must be available, per safety requirements. So, a moisture analyzer had to be purchased to measure the moisture level of the dehydrated product, so as to be able to prove the level in writing. Secondly, it was determined that most herbs do not freeze dry well, and when using this option for them, should not be used as a food garnish, but rather in soups or stew - dehydration is definitely a better method for preserving most types of herbs, since most types do not emerge from the freezing process looking good. Finally, the environment in which these food preservation processes take place strongly affects the outcome. For example, the air rack dryer process took place in a greenhouse in December, making the air very moist and adding a great deal of time to the dehydration process. In addition, where the dehydrator is placed is also an important factor. Dehydration in a very damp basement, for example, will prevent proper drying. Avoidance of undesirable temperatures and other limiting factors will increase the probability of success for the processes.

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“Hard” Herbs before dehydration

“Soft” Herbs before dehydration

Freeze-dried vs. Dehydrated Herbs

Herbs after dehydration

Dehydrated Onions and Apples (Large commercial dehydrator)

Dehydrated Apples (Large commercial dehydrator)

Dehydrated Sweet Potatoes (Large commercial dehydrator)

Project Title: CIFP -- Food Safety Software Data Management Application for Growers

Project Summary

The following information describes the results of the project coordinated by CIFT to educate Ohio specialty crop growers about the availability, cost effectiveness, and time savings that various methods of capturing food safety data can provide. CIFT reviewed food safety record management practices including data recording, data keeping, and data retrieving methodologies currently in place to understand how each system helps growers with their operations, and also, to determine what the pros and cons for each methodology are. This research will assist Ohio growers in selecting the best way to capture their food safety data specific to their operation.

There are over two thousand farmers growing specialty crops in Ohio, and each of these farms will need to comply on some level with the new food safety regulations in the very near future. While certain growers would be exempt from FSMA, many retailers will require a food safety audit regardless of a grower's size or whether an exemption may exist. David Corsi, Wegman's vice president for produce and floral operations, stated, "To us, it doesn't matter what size you are. We don't allow these exemptions." So, even those growers who are exempt are under extreme pressure from buyers and grocery chains to produce certification that their food is safe. Recording of safety data throughout the day to day operations, whether the farm is small or large is paramount to growers, so that they will be able to provide proof to buyers or auditors that they are in compliance and that their product is safe.

Growers record their safety data in a variety of ways and a small percentage do not record at all. The research for this project uncovered three methodologies currently in use among Ohio growers: paper and pen recording and storage of data in binders, a hybrid of paper and pen and excel recording with dual (both paper and electronic) storage, and software for electronic storage of data.

Maintaining records according to retailer/restaurant/wholesaler requirements, along with lower liability insurance costs and increased productivity of the people tasked with the day to day farm operations and recording of safety measures, are all incentives for keeping detailed safety records, along with increased sales and customer confidence for the grower. In addition, more Ohio growers implementing food safety measures will increase the amount of Ohio produce that retailers and wholesalers who require those measures have access to, thus reducing the amount of imported produce purchased. This would result in a decrease of transportation costs, which is a big cost saver for all. Growers using and maintaining safety records would also be able to analyze the data to determine outliers more easily, leading to potential cost savings of inputs, as well as cost savings on maintenance issues.

The purpose of this project was to provide growers with a greater understanding about farm food safety record keeping implementation, including costs and time commitments. This information will help them to decide which of the three methods will best meet their safety recording needs and overall business objectives.

CIFT's on-going activities involving food safety were the foundation for this effort. CIFT's expert network of food scientists offers a full range of food safety services to food processors and growers through microbiological consulting and testing, food safety auditing, and food safety and quality training. The organization also helps processors develop food product handling practices and procedures, including worker hygiene and sanitation practices. This food safety expertise in the food processing arena naturally carries over into the specialty crop growers' realm, and allows CIFT to apply its extensive knowledge of food safety to growers' record keeping of farm operations pertaining to safety.

The project focused on review of methodologies currently in place among Ohio growers, and then a comparison of these different methods of capturing safety data was used to illustrate strengths and weaknesses with each method. Information was then shared with growers, so that they can implement the most effective form of safety record keeping for their operation.

Project Approach

A. Identification and evaluation of record keeping methods

In 2014, the USDA reported the top ten states with farmers markets in the U.S, and Ohio came in at fourth place on the list with 311 markets. Undoubtedly, farmers markets have become a major source of food for U.S. consumers outside of the typical retail grocery store, and the safety of the food provided by the growers is paramount. The goal of this project was to identify, demonstrate, and evaluate the record keeping practices currently in use among Ohio growers. Several means were used for this project to help determine how growers were capturing safety data, including visiting farmers markets to ask growers directly, calling growers, discussing the issue at CIFT Ag breakfasts and other CIFT functions, and finally, sending out a short survey to Ohio growers to obtain their safety record keeping practices through survey responses. It was discovered through this effort that most of the smaller size growers continue to use paper and pencil, or, in some cases, paper and excel spreadsheet, to capture safety data. The larger operations tended to (although not exclusively) use software programs to record safety data. One larger grower started using software five years ago. Then, three years ago, he was audited. "The software," he said, "saved us a great headache. The ODA was blown away by our safety records." The software has also saved his operations a great deal of time over the course of the year. "Probably a month's worth of paper

and pencil in time is saved," he added. After all of the feedback and information about their safety recording methods was synthesized, a SWOT analysis was generated to help understand the strengths, weaknesses, opportunities, and threats for each of the three methodologies.

B. Demonstration of record keeping options among growers

Keeping records of all farm operations is critical, especially as it pertains to food safety. With today's complex food system, fresh produce is often handled many times during its journey from field to consumer. When foodborne illness outbreaks occur, every attempt is made to trace the illness back to the contamination and its point of origin. This makes documentation of operation processes by the grower critical. Documenting every aspect, including manure use, water test results, worker health, worker training programs, building sanitation, and equipment maintenance all provide data that can determine the origin of a contamination. At the same time, the documentation can provide data showing that the origin of the issue did *not* occur at a farm's location. Documentation also highlights a grower's commitment to safety. In speaking with growers, this topic is very much top of mind for them. The three main forms of record keeping, including pen and paper (manual), paper and excel (hybrid), and software to capture data, are all being implemented among Ohio growers. And most who use paper and pencil have thought about (and have looked into) software programs. The main deterrent for these growers to going forward with software is the cost – there is a perception that software to record safety data is prohibitive. "We are a shoestring operation. The software is too expensive for us to justify," was a common theme. Others are simply "old school", and do not want to change the way they have always done things. One grower who purchased software for his operation recently said his father would not have done so had it been up to him. His father has also not learned how to use the new technology. He prefers "hard copy" documents to data stored "in the cloud".

While seemingly more expensive than paper and pencil, there is a time savings involved in having the software monitor and record the safety data that many growers do not take into account, and that make the software less expensive than it seems. This time savings for the grower, along with the savings in supplies (of paper and binders, plus storage for the documents) can really add up. The software programs store all of the safety data in the cloud, thus reducing the need for paper, binders, and storage facilities. In addition, once the software records the data, there is no way to go back to change or manipulate any information, a plus for data integrity. Presentations to demonstrate record keeping methodologies were held at the CIFT booth at the Ohio Producers and Growers Marketing Association Congress in early 2016.

C. Conduct 5 presentations in locations in Ohio pertaining to record keeping in food safety

CIFT conducted a presentation that looked at the advantages and disadvantages of the three methods of data management. While the presentation addressed primarily food safety record keeping, it also stressed that other areas in farming should be recorded, including planting and harvesting dates, seed varieties, and any other aspect of the farm that may be useful to you and helpful to auditors.

Good Agricultural Practices (GAP) involved procedures and policies that need to be documented, to prove that growers are following these practices by maintaining accurate and timely records. There are a number of things that need to be recorded, including worker training, worker safety, equipment records, water testing records, fertilizer and other chemical records, harvest records, temperature, cleaning and maintenance, customer records including lot or date, and other

information such as soil types, seed varieties, and financials. As mentioned, Ohio growers were using all three types of data recording: pen and paper, a hybrid of pen, paper and computer, and software solutions.

For those growers using pen and paper, they will need to carry or have available at various locations the forms which need to be completed while working in the field. The forms need to be stored in a safe location with access for auditors as needed. This method is low in cost for actual materials, but can be more time consuming for the grower, so this additional time cost should be considered when determining and comparing the cost of each methodology. Some growers are interested in new methodologies for food safety data management practices. One grower said, "We use paper and pencil, but we are going to look into a software program this winter. It will be much easier to track and save time."

For the hybrid methodology where a grower uses a combination of pen, paper, and computer, the data is stored in the computer so there is not the need to store paper and binders in a storage location. However, the data in this method is often handled twice, since the farmer keeps the records during the day in the fields, and then transfers it into a computer later. This method may actually be more time consuming for this reason, however the electronic data storage is a definite plus in terms of saving materials and storage space.

The third methodology, the software option, uses a tablet based spreadsheet, or an internet connected table or even a smartphone application. The data is recorded in real time in the field or greenhouse. Data is retrieved via the computer if audited, but should be backed up to a safe location. There is no physical storage space required. There is also no handling of data twice, however the data would need to be transferred to the desktop, or a cloud based data bank. This method can be expensive, as costs would include the tablet, covers for the tablet while in the field, and the software itself. Software prices range depending upon the needs of the farm.

Another software solution, created by an Ohio grower to streamline food safety needs, works off most smart phones. Entries are made on the spot, and are recorded with a date and time stamp that can be traced to individual employees. These are securely stored on cloud based servers, and can be viewed and downloaded for auditing at any time. There is cost for this service, depending on the size of the operation. For a larger operation, having for example two packing sheds and 100 growers, the cost is about $2500 per year. For growers having 100-150 acres, it is about $350-$600 per year. The software is best suited for a farm that boxes 250,000-500,000 packages per year – which would be about 700-1500 acres. An interesting point about the software that some growers mentioned is that while there is not necessarily a large time savings with this methodology, it makes the workers more likely to actually follow the safety protocol, not just say they are following it. So, it creates a more active safety environment and culture within the operation, as opposed to a passive one.

Presentations were held in various locations throughout Ohio in early 2016 to educate growers about various methods of record keeping, maintaining data, data retrieval, and potential uses of data for analytical purposes. Over 75 stakeholder companies attended these sessions.

Conduct two webinars to educate additional stakeholders about record keeping methods
Regarding the webinars, considering the audience, it was decided that a different approach, involving reaching out to growers using both an electronic survey and an over the phone interview approach, would be of greater impact and touch more growers than a webinar. The electronic survey contained six questions including:

1. What type of data recording and record keeping do you utilize to record your food safety information?
2. If you do not use any type of software, what is the reason?
3. Would you be interested in learning about a software program that records your food safety information?
4. What would you be willing to pay for a software program that records your food safety information?
5. Have you been required to provide data reflecting your food safety plan?
6. If yes, was your method sufficient to meet the needs of the audit?

The survey was sent electronically to over 100 growers throughout Ohio, and supplemented by one-on-one phone interviews with additional growers, who were asked the same questions as above. Most of the smaller operations utilize a paper and pen or hybrid methodology, while the larger farms tended towards having a software package. The main obstacles to implementing software included cost and a preference for doing things the "old school" way. Most responded that they would be interested in learning more about a software package to track their data, but the willingness to pay for software to record safety data was on the lower end, with answers ranging from $50 to $500 dollars. Half of respondents said they had been required to provide data to reflect their food safety plan, and half of those who provided that data said it was sufficient to meet the needs of the audit.

Whichever type of record keeping a grower uses, all of the formats should include documenting practices, monitoring, and corrective actions. As a result of all of the new rules and regulations, there are many templates available for farmers to use, and tailor to their specific safety needs. Most importantly, recordkeeping should be convenient for the workers, or it will not get done. The records must be signed and dated, and it is recommended that all records be kept for at least two years. Keeping records so as to make produce safety should be a farm-wide priority, and must be incorporated into the culture of the work environment. Supporting the implementation of food safety policies and practices, providing the equipment and facilities necessary to implement practices that reduce risks, supporting effective food safety training so everyone can be actively involved in reducing risks, supporting their farm's food safety plan, and setting a good and consistent example should all be top priorities for the grower.

D. Follow up with stakeholders to determine outcomes including increases in business and/or decreases in cost associated with food safety due to implementation of software.
Many growers stated that having safety software helped them immensely when they were audited. The time savings alone was huge. Additionally, auditors were impressed with the ease with which records and data could be accessed with this methodology. One grower said having the software saved him a month's worth of time when compared with his old way of capturing data, which was pen and paper forms.

During the interactions with stakeholders regarding preferable methods of food safety record keeping, it was deemed critical to correlate the desired methods with end users. In other words, retailers/wholesalers/buyers need confirmation of GAP in order to align with their Good Manufacturing Practices (GMP). An approach towards communicating this with growers was to evaluate and design typical policies and procedures by the end user and showcase how the record keeping approach feeds into the structure. If produce was to be further processed in any way, safety procedures are applied that require proper tracking and traceability back to the field. Understanding this entire system will assist growers in evaluating which approach to integrate within their operation.

Goals and Outcomes Achieved

Identification and evaluation of record keeping methods

The goal of this project was to identify, demonstrate, and evaluate the record keeping practices currently in use among Ohio growers. Several means were used for this project to help determine how growers were capturing safety data, including visiting farmers markets to ask growers directly, calling growers, discussing the issue at CIFT Ag breakfasts and other CIFT functions, and finally, sending out a short survey to Ohio growers to obtain their safety record keeping practices through survey responses. After all of the feedback and information about their safety recording methods was synthesized, a SWOT analysis was generated to help understand the strengths, weaknesses, opportunities, and threats for each of the three methodologies.

Demonstration of record keeping options among growers

The three main forms of record keeping, including pen and paper (manual), paper and excel (hybrid), and software to capture data, are all being implemented among Ohio growers. Most growers who use paper and pencil have thought about (and have looked into) software programs. The main deterrent for these growers to going forward with software is the cost – there is a perception that software to record safety data is prohibitive. Presentations to demonstrate record keeping methodologies were held at the CIFT booth at the Ohio Producers and Growers Marketing Association Congress in early 2016.

Conduct 5 presentations in locations in Ohio pertaining to record keeping in food safety

In order to achieve this goal, CIFT conducted a presentation that looked at the advantages and disadvantages of the three methods of data management. While the presentation addressed primarily food safety record keeping, it also stressed that other areas in farming should be recorded, including planting and harvesting dates, seed varieties, and any other aspect of the farm that may be useful to the operator and helpful to auditors. Good Agricultural Practices (GAP) involved procedures and policies that need to be documented, to prove that growers are following these practices by maintaining accurate and timely records.

Beneficiaries

The target audience for this initiative included specialty crop growers, many of whom were interviewed and provided information through a variety of formats throughout the project, as well as those growers who were not interviewed but attended one of the events to learn more about safety recording protocol on farms. Secondly, beneficiaries of this research include consumers and buyers (retailers, wholesalers, foodservice venues, and more) indirectly benefit from this research, as they are the recipients of the specialty crops grown, and the safety of the food they consume is

obviously of great importance. Finally, another benefit is the increased safety of the specialty crops as result of greater safety awareness and recording of safety procedures among growers.

A Presentation entitled "Growing Agricultural Businesses through Innovative Techniques" held on December 4, 2014 was attended by 40 agricultural professionals, including educators, growers, greenhouse supervisors, hoop house managers, and vegetable consultants. In addition, CIFT distributed a survey to growers to further explore individual approaches to capturing food safety information, resulting in an additional 150 growers who were provided with information about and results from the Food Safety Software Data Management Application for Growers project. Through participation for two years in the Ohio Produce Growers and Marketers Association trade show, upwards of 400 additional growers were presented information on this advancement in data collection. At least two growers with experience relating to the software made presentations in the educational sessions to further communicate the benefits associated.

Lessons Learned

One of the first challenges was obtaining growers who would agree to participate and evaluate the various methodologies. Several agreed initially and then rescinded. Growers are busy and it is difficult to gain commitment to a project like this. There were several growers who wanted to evaluate the software solution initially, but then for various reasons declined. Surprisingly, even young, more technology savvy growers, were reluctant to evaluate the software based solution. Issues like weather, adjusted business strategies, and simply choosing to "not grow this year" were reasons given by farmers for not participating. The paper only and the paper/excel growers who signed up initially had to be replaced. Another issue faced with this demographic was the lack of interest in participating in a webinar to learn more about safety recording options on the farm. To correct this issue, a survey was sent to over 100 growers across the state, and numerous one on one phone interviews were conducted as well. Future projects involving growers need to be timed according to the farming schedule, to increase grower willingness to participate.

Contact Information

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Project Title: Midwest Apple Foundation, 21st Century APPLES (Apples for Profit, Prosperity, Local Economy, and Sustainability)

Project Summary

This project worked its way from apple seedlings to 2nd test selections to elites to identifying two new apple selections to fill the mid-season niche between the current early season standard of excellence, 'Honeycrisp' and the late season standard of excellence, 'EverCrisp'. A bevy of growers and consumers participated to enable broad and thorough apple evaluations and these two new selections have outstanding characteristics for both consumers and growers. The selections have consumer desired characteristics of flavor, texture and keeping quality. They also have grower desired characteristics of environmental adaptability to avoid spring frost, disease-

resistance to reduce pesticide application, and a fruiting habit to ensure regular cropping. These exciting new selections will be released as varieties by the Midwest Apple Improvement Association (MAIA), made available to Ohio and Midwest growers, and will ensure local growers have outstanding and unique varieties to attract consumers to on-farm and farmers markets. [Due to patenting restrictions we are unable to identify the selections by pictures or numbers in this report.]

New, consumer-preferred apple varieties 'Honeycrisp' and 'EverCrisp' make obsolete most other varieties grown in Ohio. There is a need for consumer-preferred apple varieties throughout the autumn season and a big quality gap exists in the mid-season. The Midwest Apple Foundation (MAF) is at work to create and identify such apples. This project focused on evaluating MAIA apple seedlings looking specifically for a mid-season crowd pleaser. We were fortunate to find two distinctly different apples for the broad mid-season niche. We relied on active participation by both growers and consumers to quickly and efficiently identify, and then thoroughly evaluate, mid-season candidates.

Project Approach

In Autumn 2014, forty seedlings from among 3000 seedlings of the MAIA breeding project at Dawes Arboretum were selected for evaluation. These 40 candidates were propagated onto rootstocks and planted by grower collaborators. Not all collaborators received all candidates but each candidate was evaluated by at least 10 different growers. Growers evaluated time of leafing, disease-resistance and fruiting habit during the 2015 and 2016 growing seasons. Fruit from the original seedling trees at Dawes were used to conduct extensive apple tastings at Ohio grower farm markets during Autumn 2015. A 'taste all 4; pick your favorite' format was used for on-farm tastings with the standard being the highest quality current variety of that weekend. Using this apple derby format, 14 sets of apples were evaluated by 2056 consumers with 5 outstanding potential mid-season selections identified. In Autumn 2016 these 5 selections underwent more extensive apple taste panel work assaying for fruit texture and flavor using a detailed IPAD survey involving 500 consumers. In 2016, in-depth, horticultural aspects of the five selections were studied across the wide range of locales where they were planted. Questions answered horticulturally were: When do they bloom relative to current varieties?; How easily do they set fruit?; How difficult are they to thin?; Are they disease-resistant? In addition, leaf tissue of the selections was assayed by molecular technologies to look for known markers involving fruit quality and tree traits.

Goals and Outcomes Achieved

The goal was to identify one outstanding mid-season new apple selection for Midwest growers. We were fortunate to identify two new distinctly different mid-season selections. These selections offer exceptional fruit quality (for consumers) and horticultural quality (for growers). The active participation of growers greatly contributed to the successful outcome. Likewise, the willingness of on-farm consumers to taste and express opinions of apple quality greatly contributed to the successful outcome. The direct involvement of stakeholders in this participatory project allowed us to quickly achieve our goal.

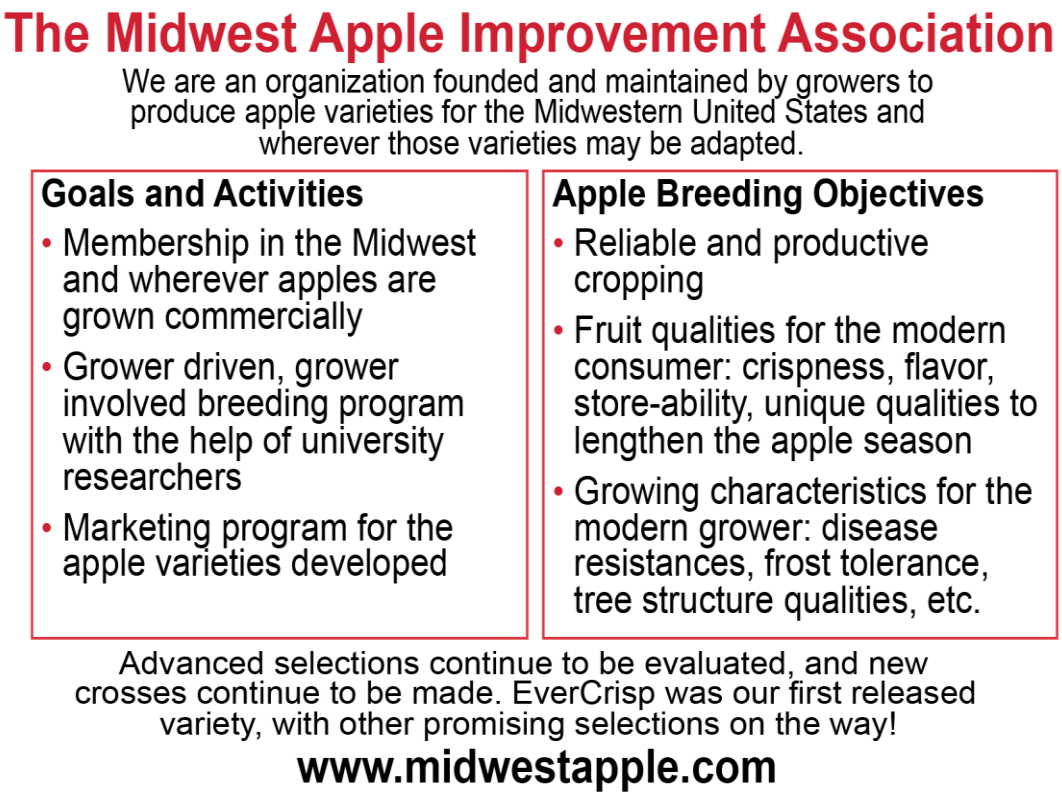
1. In consultation with Ohio Apple Marketing Program, develop information on Ohio's efforts to create 21st century APPLES (Apples for Profit, Prosperity, Local Economy and Sustainability)

Utilizing suggestions from the members of the Ohio Apple Marketing Program (http://www.ohioapples.com/Ohio_Apples_Orchards_Marketing_Program.htm) a new website for the Midwest Apple Improvement Association (MAIA) was developed (www.midwestapple.com). This website contains information on the MAIA apple breeding project, the apple breeding and evaluation process, releases from the program, and member orchards. Also a new logo was developed for the MAIA organization, representing 21st century apples:

MAIA
21st Century Apples

2. Information available as digital download on www.midwestapple.com website:
(front of postcard):

(back of postcard):



3. Distribute information to consumers: We distributed approximately 1500 of these postcards to on-farm and farmer's market consumers during apple tasting events.

4. Make information available to growers to distribute to consumers: Postcards were made available to growers and marketers to display at their sales venues to inform consumers of their involvement in the MAIA breeding project. Approximately 1000 postcards were distributed to growers for this purpose.

5. 2,000 hard copy information bulletins distributed and information also available in digital form as download. This was achieved as noted above.

Beneficiaries

Currently the main beneficiaries are the Ohio growers who participated in this project and who are aware of the quality of these two new selections. This number of beneficiaries will soon expand to include the cohort of MAIA growers who will request trees of these new selections and start to grow them (there will be a 2 year gap here for large quantities of trees of these new selections to become available). Within 5 years the beneficiaries will be Ohio/Midwest growers who are offering these high demand selections for sale at their markets AND the Ohio/Midwest consumers who are seeking these selections out and are willing to pay a premium for them.

Apple growers are a beneficiary of this project. During this Midwest Apple Foundation project membership in the Midwest Apple Improvement Association grew from 250 orchards to 395 orchards (The Ortet, fall 2016 http://www.midwestapple.com/_PDF/_Newsletters/ORTET2016.pdf). This demonstrates the success of the breeding project and the ever-widening acceptance of the new apples beyond 'first adopters'.

Consumers are a beneficiary of this project. We focused on local apples for local markets and creating a distinction between 'grocery store apples' and new MAIA apples which are available from local orchardists. Certainly the willingness and excitement of consumers to taste and rate the MAIA apples generates a buzz for local marketing. Unfortunately there is a lag between when these apples are selected and the 2-3 years it takes for growers to get trees and get them into production and the fruit into their markets. The buzz is building however. The Columbus Dispatch ran a front page comprehensive article on the MAIA breeding project (Sunday October 9, 2016: http://www.dispatch.com/content/stories/business/2016/10/09/1-quest-for-perfect-fall-fruit-takes-years-results-in-evercrisp.html) and demand for MAIA new apples is far outreaching supply.

Lessons Learned
The main lesson learned is that this previously long-term apple selection and evaluation process can be streamlined and speeded up by involving lots of collaborators. For that to happen however, the stage needs to be set by having seedlings ready to evaluate and a team of collaborators ready to participate, and having the funding and leadership to enable the process.

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Project Title: Ohio Maple Producers Association (OMPA): Maple Ohio

Project Summary
The Ohio Maple Producers Association (OMPA) applied for the Specialty Block Grant to increase awareness of the Ohio maple industry to Ohio consumers. Our goals were to increase participation in the Maple Madness driving tour by producers opening their farms to tours and consumers visiting the tour stops. We hoped to increase farm revenue through increased sales by direct sales to participants on the tour and later sales of Ohio maple syrup both farm gate and through retail

outlets. The second goal was to start the Ohio Maple Magazine that would be directed at consumers to promote maple syrup consumption in non- traditional ways and generally promote a hidden industry to too many Ohioans.

Project Approach

OMPA hired a project administrator to coordinate the Maple Madness tour and publish the Ohio Maple Magazine. The administrator was responsible for sending letters of invitation for participation in the maple tour and advertising in the Ohio Maple Magazine. The letters were followed up with further contact to encourage participation. The administrator then developed and edited a tour pamphlet for advertising the Maple Madness Driving Tour. OMPA members promoted these activities at an industry trade show, the winter producer meetings hosted by OSU Extension, and the OMPA annual meeting. The administrator was responsible for distribution of the pamphlets to tour stops, visitor centers, tourism bureaus etc. Paid advertising in eighteen to twenty print media publications was purchased to promote the tour to the public. Numerous articles in small and large market newspapers highlighted the maple industry and the driving tour. The OMPA website was used as an online medium to promote and provide information for the tour. All tour sites, their activities description, and directions to tour stops were listed. The administrator was also responsible for selling advertising, editing, and publishing the Ohio Maple Magazine.

The Maple Ohio project resulted in an increased consumer awareness of the Ohio Maple industry. Forty-five maple operations in twenty-two counties invited Ohioans to visit and have a maple experience through the Maple Madness Driving Trail. Twenty thousand copies of the Maple Ohio Magazine were printed and distributed statewide.

Goals & Outcomes Achieved

We feel very positive about the results from using the Block Grant to promote the Ohio maple industry. The numbers of tour stops were 45 in 2015 and 47 in 2016. Most stops were satisfied with the number of visitors and product sales. Most producers have seen an increase in sales of ten to fifteen percent over the last two years. The NASS report indicates the Ohio Maple industry is in decline. We feel it is a reporting issue and inaccurate for the industry due to the number of dealers selling maple equipment has doubled in the last five years. Most producers have made improvements to sap collection systems to increase yields. The price of maple syrup sold bulk has declined from record highs but it is still profitable. The use of the SCBG to promote tour stops to let people experience maple syrup production raised awareness to the public but more showed Ohio producers the benefit of educating consumers how we produce our product. The increase traffic on the OMPA website is an indication of our reach to potential customers. In 2014 we had 306,270 hits and 26,075 visits, in 2015 333,630 hits and 28,765 visits, and in 2016 348,001 hits and 33,679 visits. The improvements to the OMPA website were done using OMPA funds.

The second goal of starting a Maple Ohio magazine is progressing. The 2016 magazine was changed to a glossy print consumer oriented magazine. The response from producers was mixed but many people said it was a magazine they would keep for the recipes and information. The best indication this will be an ongoing project is the increase in advertising for 2017. We will be able to fund both the tour and magazine in 2017 with funds generated from the industry. This was not possible in 2014. An unexpected result has been assistance from Farm Bureau and tourism groups showing interest helping promote the tour.

Beneficiaries
Beneficiaries from this grant project include the administrators, magazine contributors, editors, publishers, printers, and paid advertisers. The success of the project means these people will have annual revenue from this project. The forty five to fifty operations that participate in the tour will see a direct increase in maple season sales. The more difficult benefit to measure is how OMPA's efforts help the maple industry. We have partnered with other states to promote March as maple month. Events from all the maple producing states and Canadian Provinces are on a website directing potential customers to maple producers and their events. Sales of maple products are steadily increasing ten to fifteen percent per year. The maple industry is only one percent of the sweetener market. Our market growth potential is vast. The resent research in the health benefits from maple syrup from the vitamin, minerals, and antioxidant content in maple syrup has caused much interest in our product. There are increases in nontraditional uses of maple syrup from maple liqueurs and maple beer, bourbon barrel maple syrup, maple bacon and other cured meats, used as a sweetener in health drinks to more traditional box store baked goods. Increased sales benefit all producers in Ohio and the Maple Madness driving tour and the Maple Ohio Magazine are a part of the effort in promoting Ohio Maple and the use of maple products worldwide.

Lessons Learned
The biggest challenge we had in this project was continuity. The 2015 project manager had to resign and it was difficult to fill that position timely. The 2016 project was rushed as a result. Having a paid administrator to handle the day to day issues and coordinate the event was very good. The tour is slowly growing to all areas of Ohio instead of a mainly Northeast Ohio event. Hopefully, the current tour administrator and magazine editor will be a long term partnership. We gave producers the flexibility to set their days and hours over the tour weekends. This worked well in 2015. In 2016 we decide to let folks have their event anytime in March instead of two weekends. We were going with the March is Maple month idea. This created more confusion than convenience. We are going back to two set weekends. Generating funds through magazine advertisements will provide funds to administer the 2017 tour.

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Project Title: ONLA: Plant Something Campaign Marketing Support

Project Summary
The Ohio Nursery and Landscape Association coordinated a seasonal promotional and educational campaign for home gardeners throughout the state of Ohio as part of the national *Plant Something* movement. *Plant Something* is an established campaign that increases the public's support of local growers, nurseries, garden centers, and landscapers by building awareness of the benefits of planting landscapes and gardens.

Utilizing print, online, and social media communications and partnering with independent garden centers across the state, ONLA's campaign, *Fall is for Planting*, educated home gardeners on the benefits of planting in the fall, while encouraging them to take action.

While most home gardeners think of spring as the best time to plant a garden or design a landscape, ONLA's *Fall is for Planting* campaign educated consumers on the many benefits of planting in the fall. Some of the easiest, and most rewarding landscape plants to plant in the fall are spring-blooming bulbs such as tulips and daffodils.

ONLA's *Fall is for Planting* educational campaign was designed to increase knowledge of the many benefits of landscape plants and inspire action among home gardeners to "plant something". In turn, the campaign increased awareness and patronage of Ohio's nursery industry during what is typically a slow period for garden center sales.

Project Approach

Educational information on the benefits of planting in the fall was disseminated to a state-wide audience through ONLA's social media networks and ONLA's consumer website BuckeyeGardening.com, which provides resources for home gardeners and connects consumers with Ohio's garden centers and landscape companies.

ONLA provided an incentive for consumers to participate in the *Fall is for Planting* campaign with a 10-day promotion in partnership with 31 independent garden centers across the state. This promotional campaign centered around a paper bag coupon distributed to 550,000 households through 14 Ohio newspapers.

Consumers were encouraged to bring their paper bag to their participating local garden center to receive six free daffodil bulbs. The bags also encouraged consumers to visit Buckeyegardening.com for information on how to plant and care for spring-blooming bulbs and to learn more about the *Plant Something* and *Fall is for Planting* movements.

Approximately 1,000 additional bags were sent to each participating garden center for distribution to customers. Participating garden centers joined the campaign by spreading awareness of the promotion through on-site signage, on their social media networks, websites and email newsletters.

Goals & Outcomes Achieved

A post-campaign survey of the participating garden centers was conducted. Consumers redeemed a total of 3,661 bags. With an average of $15.24 spent by each customer who took advantage of the promotion, garden centers reported a total of $55,793.64 in additional revenue from the campaign.

In the post campaign survey, 83% of the participating retail garden center said they were pleased with the outcome of the campaign and 50% reported receiving new customers because of the promotion.

In the post campaign survey of participating garden centers, 50% of those garden centers reported receiving new customers because of the promotion. While measurable increases in customers were not tracked, the garden centers reported a total of $55,793.64 in additional revenue during the promotional period.

A consumer survey was not added to the website asking for awareness feedback due to staff turnover.

A post-campaign survey was not conducted due to staff turnover. However, the Buckeyegardening.com website, an educational website for home gardeners, received 729 web visits and 1,809 page views during the 10-day campaign, which was approximately 50% higher than the previous 10-day period.

The Buckeyegardening.com website received 729 web visits and 1,809 page views during the 10-day campaign, which was approximately 50% higher than the previous 10-day period. The BuckeyeGardening.com website includes informative articles for home gardeners and links to the national Plant Something website with educational information about the environmental and economic impact of landscape plants. During the promotional campaign, the site received 729 web visits and 1,809 page views during the 10-day campaign, which was approximately 50% higher than the previous 10-day period.

Beneficiaries
Home gardeners in 550,000 households received information about the benefits of planting in the fall and an opportunity to beautify their home landscapes at a low cost. The 31 participating retail garden centers, all independently owned, small businesses, received raised awareness and increased revenue during what is typically a slow period for sales.

Lessons Learned
Since this was a new process for the ONLA staff, more lead time should have been allocated for the purchasing, designing and printing of the paper bags used in the promotion, as well as the purchasing of insertion ads and the distribution of the paper bags to the 14 Ohio newspapers.

The results of the campaign indicated that educational campaigns are most successful when coupled with an incentive to act. Similar awareness campaigns could be offered throughout the year, serving as consistent, yet non-intrusive reminders about the importance of planting and maintaining home landscapes and gardens.

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Project Title: OSU --Development of economically and environmentally sound hop production and processing guidelines to support Ohio's growing Craft brewing Industry

Project Summary

The craft brewing industry in Ohio continues to grow, and with that the need for Ohio grown specialty crop ingredients including hops. Ohio craft brewers spend an estimated $30 million annually importing hops from outside of Ohio. Hops, flowers of the hop plant, are a main ingredient in beer manufacturing, providing a bitterness that balances the sweetness of the malt sugars and a refreshing finish. Based on the increased interest in buying and growing locally produced hops, The Ohio State University evaluated new hop varieties, nursery propagation, irrigation, fertility, insect and disease control methods, processing, food safety and marketing techniques. Data collected from applied field research trials has allowed us to educate growers about Ohio hop production, pest management practices, hop plant propagation, processing and marketing.

The purpose of this project was to further develop commercial hop production in Ohio, a specialty crops industry that is growing rapidly. Ohio supports an expanding brewing industry with over 180 licensed beer manufacturers and this number is increasing yearly. Ohio growers are poised to capture the $30 million dollars in sales and related jobs currently sourced out of state by Ohio's growing craft brewing industry. An estimated 170 acres of hops are now being grown in Ohio in 2016 up from 20 acres in 2012; however growers continue to face many challenges. The number of reported outbreaks of hop diseases and insect pests are on the rise and growers had lacked the research, tools and training to profitably manage them. Following harvest, few options exist on how to conduct on farm processing and to comply with the associated food safety & quality standards required by the brewing industry and regulatory agencies. Therefore, innovative farm processing strategies and guidelines have been developed that are economically feasible and meet important food safety standards. Finally, new growers need access to detailed information and resources to be able to make informed economic decisions to grow their hop business this project has provided these educational resources.

Project Approach

Our objective-based activities for this project were:

1) Develop and publish a protocol for insect, disease, irrigation and fertilization management for Ohio hop production.
2) Establish an additional Northwest Ohio hop field research site to better inform statewide management recommendations and to collect unbiased research based information for all Ohio growers.

3) Advance an established method to process high quality food grade hop cones for use in beer production.
4) Develop an online module "Growing Hops: From Planting to Processing" to provide growers with tools to be successful in this growing industry.
5) Provide educational training on all aspects of hop production through field days, an annual winter workshop, regional workshops & trainings and a project website.
6) Develop a hop rhizome and plant propagation protocol that can be adopted by Ohio growers to facilitate the development of an Ohio grown hop plant propagation industry.

Goals and Outcomes Achieved

Develop and publish management protocols for insect, disease, irrigation and fertilization management for Ohio hop production.

Overview/Need: Hop production and management curriculum was developed to teach growers of the management protocols necessary to grow and adopt hops as a viable alternative agricultural enterprise to capture a ready-made $30 million dollar Ohio craft brewery market.

Curriculum Description: Management plans and growing protocols for insect, disease, irrigation and fertilization management were developed using unbiased research based information obtained from Ohio field research results. This curriculum was published in the form of fact sheets, Integrated Pest Management guides, lesson plans, reports and fact sheets. This information was presented and taught to farmers at workshops and field days throughout Ohio and published in specialty crop newsletters. This information is available for download on the Ohio Hops web site. Consists of prepared lesson plans, worksheets, teaching outlines, presentations and web based materials such as fact sheets, drying calculators and production budgets from unbiased research based university sources. This curriculum can be modified to be used for a 45 minute program or for a day-long workshop. The Curriculum was developed as a team effort with Bergefurd providing field production and crop management data and expertise; Dr. Mary Gardiner, the Ohio State University Department of Entomology providing insect pest management and control data and expertise; and Dr. Sally Miller providing disease management and control data and expertise. The management protocol curriculum was designed using production and management data gathered from applied field research hop experiments.

Hops Disease Diagnostics & Beneficiaries

To assist with development of disease management protocols, lab diagnostic services were provided to Ohio hop growers to determine what disease pathogens Ohio growers are experiencing and to develop control recommendations and educational resources.

SUMMARY 2015/2016

Year	Diagnosis	Counties (# per county)
2015	Abiotic	Medina (1)
	Alternaria cone disorder	Defiance (1), Wayne (1)

	Apple mosaic virus	Ross (1)
	Apple mosaic virus and Carlavirus	Pike (1), Ross (1)
	Downy mildew	Summit (1), Wayne (1)
	Phytophthora root rot	Wood (1)
	Two-spotted spider mite	Erie (2)
	Not diagnosable	Defiance (1)
2016	Abiotic	Ashland (1), Franklin (1), Mahoning (1), Wayne (2)
	Alternaria cone disorder	Warren (2), Wayne (1)
	Apple mosaic virus	Licking (1), Wayne (2)
	Chemical Burn	Mahoning (1), Unknown (1)
	Downy mildew	Geauga (1), Medina (1), Pike (15)
	Insect damage	Warren (1), Wayne (1)

Data

Date	**County**	**Diagnosis**
5/13/15	Summit	Downy mildew
5/13/15	Wayne	Downy mildew
6/17/15	Ross	Apple mosaic virus
6/18/15	Defiance	Not diagnosable
6/23/15	Ross	Apple mosaic virus and Carlavirus complex
6/30/15	Defiance	Alternaria hops disorder
7/16/15	Pike	ApMV positive/Carlavirus
7/24/15	Wood	Phytophthora root rot
7/30/15	Wayne	Alternaria disorder/ early maturing
8/7/15	Medina	Abiotic – likely pesticide residue
8/19/15	Erie	Two-spotted spider mite damage
8/19/15	Erie	Two-spotted spider mite damage
4/26/2016	Medina	Downy mildew
5/20/2016	Wayne	Downy mildew

5/24/2016	Wayne	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
5/27/2016	Pike	Downy mildew
6/21/2016	Shelby	Downy mildew
6/28/2016	Geauga	Downy mildew
6/29/2016	Franklin	Abiotic (over fertilization)
6/29/2016	Mahoning	Chemical burn
7/13/2016	Wayne	abiotic
7/13/2016	Wayne	abiotic
7/13/2016	Wayne	ApmV (mild)
7/13/2016	Wayne	Chemical burn
7/21/2016	Licking	Apple mosaic

7/27/2016	Mahoning	Abiotic disorder
8/22/2016	Ashland	Abiotic
8/24/2016	Warren	Alternaria cones disorder
8/24/2016	Warren	Alternaria cones disorder
8/24/2016	Warren	insect damage
8/24/2016	Warren	Insect damage
8/29/2016	Wayne	Insect damage
10/8/16	Wayne	Alternaria Cone disorder
10/8/16	Wayne	ApMV

Establish a Northwest Ohio hop demonstration and education site to teach management recommendations and to demonstrate hops production techniques for all Ohio growers. Establishing direct connections between the Northwest Ohio brewing industry and growers through this two-year project improved producer access to Ohio's beer manufacturing markets and price ranges willing to be paid by Ohio beer manufacturers was gathered. We provided project information to growers through educational programs held at OSU-OARDC, OSU Extension, AIF, CIFT and OSU South Centers. These programs covered all aspects of hop production and marketing. Field days were held at the Bowling Green location in August of 2015 and 2016.

EVALUATE NW OHIO HOP PRODUCTION AND QUALITY

Hop Yard Established

- A ½ acre hop yard (AIF- Bowling Green, Ohio)
- Site preparation (deep till, install drainage as needed, add compost, form beds)
- Soil fertility (soil test, apply lime and nutrients as needed)
- Install low trellis system (20 ft. high trellis, plants spaced at 3 ft. within a row, 10 ft. between rows. Each yard will consist of 6 rows, 18 plants per row.
- Transplant rhizomes started in the greenhouse and planted directly to the field and train to trellis (cultivars preferred by Ohio Craft Brewers).
- Installed, irrigated and fertigated with drip tube on a regular schedule.
- Applied landscape fabric mulch to hold soil moisture and deter weed growth.

Evaluation of Hop Cultivars

- Measured phenology (bud break, flowering, cone set, maturity).
- Measured winter hardiness .
- Scouted for two spotted spider mite, hop aphid and other potential arthropod pests using weekly leaf counts.

- Applied insecticide to all plants within a cultivar if counts exceed 10 mites or aphids per leaf.
- Inspected plants weekly for signs of disease (including downy mildew, powdery mildew, and verticillium wilt).
- Followed recommended field sanitation and fungicide application to manage for any disease detected.
- Harvested cones, determined yield and cone weight.
- Assessed cone quality using Kar laboratories (% Alpha Acids, beta acids). Ohio Craft Brewers Association members evaluated quality of beer produced with Ohio-sourced hops.

SUPPORTING HOP GROWERS TO PRODUCE AND MARKET NORTHWEST OHIO HOPS

- Hosted field days and workshops in 2015 and 2016 at hop yard. Taught cultivar selection, trellising options, weed management, disease management, arthropod management, harvesting, and marketing.

Timetable (Spring 2015-Fall 2015): The high trellis was established spring 2015 in Bowling Green, OH. In Spring 2015 and 2016 rhizomes and plants were planted in the greenhouse (mid-May) and/or transplanted to the field. Insect and disease scouting occurred from May - Harvest 2015 and 2016. Field days were held summer 2015-16. Extension programs focused on hops production were held in Fall 2015/2016.

The Ohio State University Bowling Green hop yard:

This project established a ½ ac. hop yard containing 10 hop cultivars at the Ohio State University's John E. Hirzel Sustainable Agriculture Research and Education Site in partnership with support from the Agricultural Incubator Foundation (AIF), Hirzel Farms, OSU Extension Wood County, OSU South Centers (Piketon, Ohio), OSU Department of Entomology-OARDC (Wooster, Ohio) and the Center for Innovative Food Technology (CIFT) (Toledo, Ohio) We evaluated phenology, cold hardiness, disease and insect resistance, yield and cone quality. We evaluated the quality of the hop cones produced by examining the % Alpha Acids, beta acid levels, brewing characteristics and processing of harvests. By fall, 2014 preliminary production protocols were developed, and initiated spring of 2015 & 2016.

High trellis system (17 ft.) was installed and rhizomes/plants were planted. The hop yard consists of 10 rows of 18 plants for a total of 180 plants per hop yard. There are 10 varieties planted at each site in a complete block design.

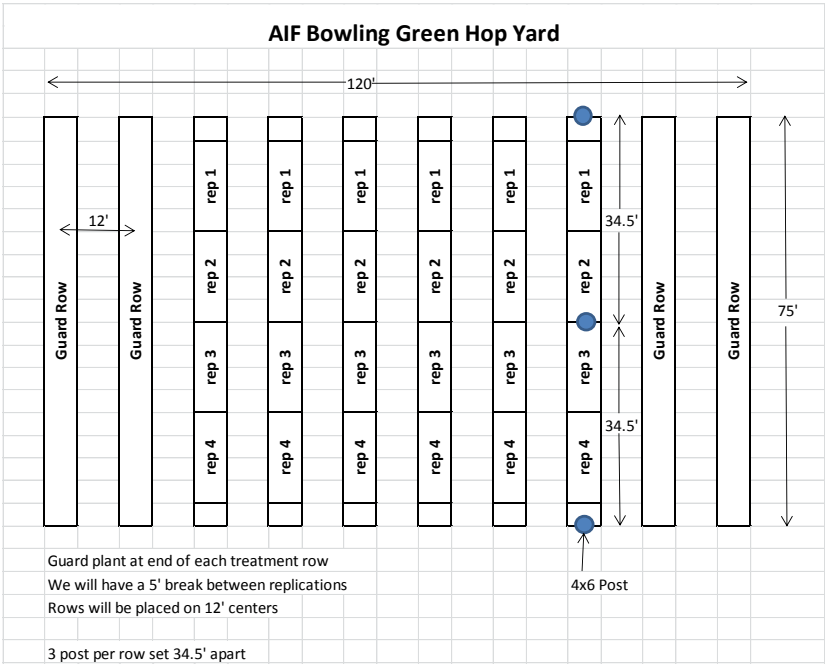

Figure 1: Bowling Green Hop Yard Plot Map.

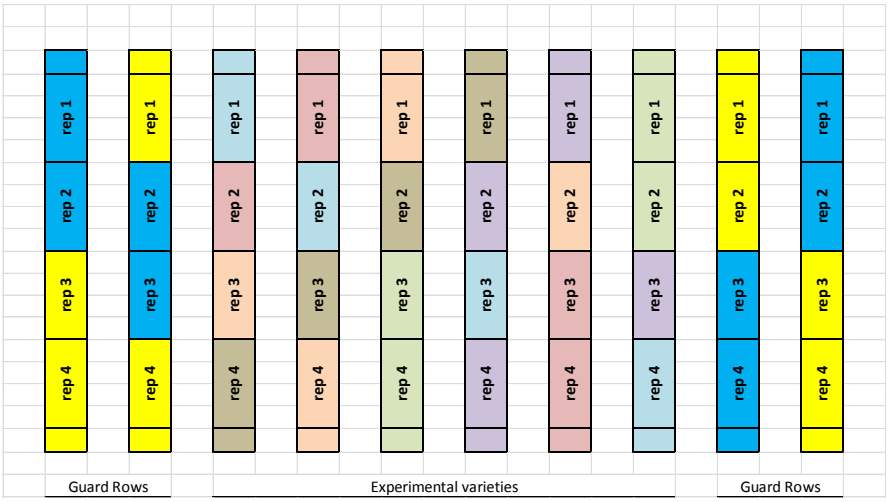

Figure 2: Bowling Green hop yard Randomized Treatments.

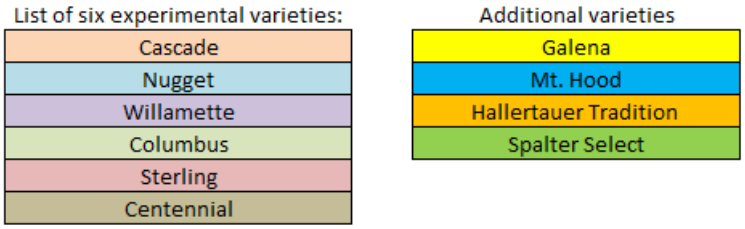

Figure 3: Varieties planted at Bowling Green hop yard.

The experimental varieties are those which we collected data from. The additional varieties are planted in single replications and data collected is for observational and quality testing purposes only. We documented the steps of development of the Bowling Green hop yard trellis construction, planting and management with photographs which can be viewed on this web site: http://go.osu.edu/osu_aifhopsproject

Bowling Green Hop Yard in the Media:
The Bowling Green hop program was highlighted in several northwest Ohio media releases in 2016:
http://www.sent-trib.com/news/crop-of-hops-brews-interest-at-incubator/article_677e694a-6ac8-11e6-a1cd-93910ca81aee.html

http://www.sent-trib.com/community/hops-to-it-at-ag-breakfast/article_0a3b28a2-6156-11e6-888a-d71e1c125404.html

We collected the following data from the research trial.
Pest presence (leaf observations): Leaves were collected from the hop yards weekly for counts of two-spotted spider mite and hop aphid (two major hop pests). Neither was detected prior to harvest in 2015 or 2016. During the 2015 growing season hop aphids and two-spotted spider mites were detected at low levels which did not cause economic damage the harvested cones.

Disease: In 2015 we did not apply fungicides to the hop yard. Following harvest (2015), members of the Hop Team examined plants for disease. Downy mildew was detected. In 2016 downy mildew was detected in the Bowling Green hop yard. We sprayed fungicides according to suggestions from the OSU Plant Pathology Dr. Sally Millers Lab.

Yield data: We collected and analyzed yield data for the six experimental varieties in 2015 & 2016 from all three hop yards. After the hop cones were harvested they were dried with an oats (hop dryer), weighed, and packaged with a vacuum sealer. Yield data for 2015 & 2016 is included in the tables below:

Table 1: Hop Yields Piketon, Ohio 2015

Cultivar	Wet lbs. per Acre	Wet lbs. per Plant	Dry lbs. per Acre	Dry lbs. per Plant
Nugget	2872 A	2.3735 A	1070 A	0.8843 A
Columbus	2670.2 A	2.2068 A	877.6 A	0.7253 A
Cascade	1484.6 B	1.227 B	482.2 B	0.3985 B
Sterling	1017.4 BC	0.8409 BC	307.2 BC	0.2539 BC
Centennial	503.7 C	0.4163 C	161.2 C	0.1333 C
Willamette	218.2 C	0.1803 C	52.6 C	0.0435 C
LSD	**874.34**	**0.7226**	**313.65**	**0.2592**

** Treatments with the same letter are not significantly different.*

Table 2: Hop Yields Wooster, Ohio 2015

Cultivar	Wet lbs. per Acre	Wet lbs. per Plant	Dry lbs. per Acre	Dry lbs. per Plant
Columbus	3505.8 A	2.8973 A	2081.4 A	1.72016 A
Nugget	2560.3 B	2.1159 B	1520 B	1.25623 B
Cascade	2346.7 B	1.9394 B	1393.2 B	1.15143 B
Sterling	1620 C	1.3389 C	961.8 C	0.7949 C
Centennial	985.7 D	0.8146 D	585.2 D	0.48366 D
Willamette	828 D	0.6843 D	491.6 D	0.40629 D
LSD	**420.16**	**0.3472**	**249.45**	**0.2062**

** Treatments with the same letter are not significantly different.*

Table 3: Hop Yields Bowling Green, Ohio 2016

Treatment	Wet lbs. per Plant	Dry lbs. per Plant	Wet lbs. per Acre	Dry lbs. per Acre
Columbus	1.5738 A	0.38326 A	1904.3 A	463.74 A
Chinook	1.3298 A	0.34163 A	1609.1 A	413.37 A
Galena	0.6613 B	0.16905 B	800.2 B	204.55 B
Cascade	0.4609 BC	0.11123 BC	557.7 BC	134.59 BC
Nugget	0.2428 BC	0.05705 C	293.8 BC	69.03 C
Centennial	0.1872 C	0.04901 C	226.5 C	59.3 C
Mt. Hood	0.1267 C	0.03359 C	153.2 C	40.64 C
Willamette	0.1162 C	0.02753 C	140.6 C	33.31 C
Sterling	0.0804 C	0.02037 C	97.3 C	24.65 C
Golding	0.0356 C	0.00925 C	43 C	11.19 C
LSD	**0.4294**	**0.105**	**519.52**	**127.08**

**Treatments with same letter are not significantly different.*

** All results based on 1210 plants per acre*

Table 4: Hop Yield Piketon Ohio, 2016

Treatment	Wet lbs. per Plant	Dry lbs. per Plant	Wet lbs. per Acre	Dry lbs. per Acre
Nugget	0.7729 A	0.24229 A	935.2 A	293.17 A
Columbus	0.7605 A	0.25771 A	920.2 A	311.83 A
Cascade	0.5763 A	0.14345 B	697.3 A	173.57 B
Sterling	0.2673 B	0.08095 BC	323.5 B	97.95 BC
Centennial	0.1297 B	0.04791 C	156.9 B	57.97 C
Willamette	0.0396 B	0.01156 C	48 B	13.99 C
LSD	**0.2683**	**0.0824**	**324.6**	**99.673**

**Treatments with same letter are not significantly different.*

Table 5: Hop Yield Wooster, Ohio 2016

Treatment	Wet lbs.	Dry lbs.	Wet lbs.	Dry lbs.

	per Plant	per Plant	per Acre	per Acre
Columbus	3.3171 A	0.94218 A	4013.7 A	1140.04 A
Cascade	2.024 B	0.56077 B	2449 B	678.53 B
Nugget	1.7069 B	0.51192 B	2065.4 B	619.43 B
Sterling	1.1289 C	0.30396 C	1365.9 C	367.8 C
Centennial	0.8597 CD	0.23629 CD	1040.2 CD	285.91 CD
Willamette	0.4926 D	0.13309 D	596.1 D	161.04 D
LSD	**0.4535**	**0.1237**	**548.78**	**149.69**

**Treatments with same letter are not significantly different.*

In 2016, the first harvest year at the Bowling Green hop yard, the Columbus variety produced a significantly higher yield than the other five varieties tested at both sites ($p < 0.05$). Being the first year of production this is the expected result. Hop plants typically do not produce much yield within their first three growing seasons as the plants direct most of their energy towards producing root systems.

In 2016 Wooster's highest yielding variety was Columbus, while cone production by Nugget was greatest in Piketon. This indicates that the performances of particular varieties may vary across Ohio. We are expecting peak production starting the third season at the Bowling Green Hop yard in 2017.

Advance established methods to process hop quality cones for use in beer production.
Since the development of Ohio hops production began in 2013 the proper processing and handling requirements for dried cones have been discussed among, brewers, growers, and the regulatory agency the Ohio Department of Agriculture (ODA). Producers as well as the ODA in the early development stages were not aware of the food safety and regulatory guidelines that had to be met and followed in order to process and sell hops on the open market. This resulted in several growers being warned and fined for not following proper processing protocols and food safety regulations enforced by the ODA.

Food Safety Regulations
In 2014 the ODA working with the Ohio State University and members of the Ohio Hop Growers Guild came to a consensus of the standards that must be followed by Ohio hop growers to process hops. After discussions and comparisons with other states, Ohio was holding its growers to much more stringent and fairly expensive practices than the other 49 states. Working with the USA Hops Organization, the Ohio Hop Growers Guild and the ODA, in 2015/2016 these Ohio regulations were amended and are in-line with other parts of the United States. Also hop processing protocols and quality standards were developed.

Ohio Department of Agriculture (ODA) has tentatively changed its view of hops as Raw Agriculture Product (RAP) up to the point that cones are pelletized. The ODA's previous view was that hops were considered a RAP as soon as they are dried (in an oats). This change will mean that

hop growers in Ohio who do not pelletize hops on their farm will no longer be required to have their oats or drying facility inspected by the ODA. For growers who do pelletize, this will mean that only their pelletizing room (or facility) will need to be inspected – not their oats. This will reduce the capital investment cost for most beginning hop growers.

The newly established hop processing and food safety guidelines for ODA Food Safety Compliance and Licensure are as follows:

- Drying Oast must operate in a space that has EASILY CLEANABLE, WASHABLE SURFACES. Examples: A partitioned area of a barn, garage, outbuilding in which the floors, walls, and ceiling can be washed. Dirt floors are NOT compliant, nor an area open to animal manure, bird nesting, rodents, etc. A WASHABLE SURFACE can be made of FRP board, Stainless Steel, Food Grade Plastic, or Latex Painted (beware of chipping or flaking paint) or Polyurethane Sealed Wood.
- Any porous surface in contact with the wet and dry hops must be sealed, in order to create a barrier against bacteria remaining on the surface. We do not want to create crevices which can harbor bacteria. Examples: A food grade plastic tray which holds the hops, a food grade mesh, or a painted or plastic-coated tray.
- Enclosed Light Fixtures/Shatter-proof Bulbs
- Hand Washing Station. Example: Igloo cooler with soap, paper towels and trash receptacle

Hop Processing Protocol

To assist, educate and guide growers of the proper methods for taking hops from the field and preparing for brewers a hop processing protocol was established in cooperation with the Ohio Hop Growers Guild hop quality Standards Committee.

Flow Chart to Illustrate the Process of Taking Raw Field Material to Brewery-Preferred Hop Pellets

HOPS IN THE YARD

- Hops Are Ready to Harvest When Moisture Content of Hops in field are at 80 %
  - Smell, Sight and Sound of the Hop Cone are also indicators of ripeness
- 20-feet Mature Hop Bine and Coir String are cut releasing them from the Top Wire of the Trellis System using a Scaffolding Platform pulled by a Tractor. Then, Field Workers Cut the Bine and String from the Lower Wire
- Bines are then laid in an organized manner onto a second wagon to be in position to feed into a Harvester

↓

HARVESTER/HOP PICKER

- Handpicking – Historically, hop bines were handpicked by women and children of the farm and would take over an hour to pick one bine.

- Self-Built Hop Picker (various designs can be found online)
- Mobile Harvester, which can be used right out in the hop yard (pickers available from various manufacturers)
- Stationary Hop Picker, for example Wolf WHE 170 Hopfen Pflückmaschine, which means "A Hop Picking Machine," and manufactured in Germany by the Dauenhauer Manufacturing Company. Picks 170 bines in 1 hour.

↓

DRYER

- The dryer, or "oast" is a unit with circulating fans to move air across hops which rest on drying screens. Can be built by farmer using ODA criteria.
  - This piece of the processing is very critical.
- If you dry too quickly with heat above 140 degrees, you degrade oils (or lupulin) in the cones that give you its aroma and value.
- If you dry too slowly, the material can begin to degrade, also affecting the quality of the chemicals in the flowers that brewers rely on.
- Moisture readings are taken throughout the 18-24 hour process to ensure the hops are dried to between 8 – 10 % moisture, reducing the hops to 30% of the green weight. Hops are removed from the drying floor and cooled/conditioned for 24 hours. This allows for the best storability.
- Any farm which dries hops and processes them from this point forward must be inspected and licensed by the Ohio Department of Agriculture, since it is now considered a food product.
  - Hops are then sent to the Baler.

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BALER

- Dried Hop Cones are compressed into 50 – 200 # Bales to reduce space requirements until hops are used. There are different fabricated balers and just need to compress to a safe level as to not damage oils
  - Farmers have used trash compactors or modified log splitters to compress hops

↓

COOLER

- Until Baled Hops can be processed further, they need to be stored in a cool space between 32 – 34 degrees. Again, this is to protect the quality of the hop flower and lupulin. Heat equals degradation of the product.)

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HAMMERMILL/GRINDER

PELLET MILL

- Dried hops are hammered into a powder and then compressed and extruded through a die to create a T-90 pellet.
- Care must be taken to keep the temperature below 120 degrees during this stage as to not compromise the integrity of the hop oils.

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PACKAGER

- Hops are vacuum packed into Mylar Bags (light and moisture barrier). They are back-flushed with nitrogen in order to reduce oxidation and retain freshness.
- Hops are packaged in various size bags depending on customer
- 1-2 oz. pouches for home brewers, 1 # bags, 5# bags, 11# bags, 22# bags and even 44# bags for high-volume breweries

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LAB TESTING

- Hops are tested by specialized lab in order to measure Alpha Acids, Beta Acids, Moisture Content, HSI as well as other chemical content
- This is done according to American Society of Brewing Chemists (ASBC) Methods
- Chemical Analysis is needed by brewers to ensure brewing success

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LABELING

- Each package of hops must be labelled with Farm, Type of Hop, Wt., Harvest Date to be in ODA compliancy

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STORAGE/COOLER/FREEZER

- Hops must continue to be held in cold storage to minimize oxidation
- Deep Freezer if not used within 3 months

↓

OFFICE/ADMINISTRATION

MARKETING/SALES

LOGISTICS/DELIVERY

- Be sure to have the necessary support procedures set up in order to get your hops in the hands and kettles of Brewers.

J. Napier, Barn Talk Hops 2016

Hop Quality Standards

To assist and guide growers to produce the highest quality hops to satisfy brewer/buyer demands a list of hop quality standards has been developed, for there have been no hop quality standards established in Ohio. These standards will be constantly updated and revised according to brewer and craft brewing industry feedback. These Ohio hop quality standards were developed in cooperation with brewers, University experts, and grower's protocol in cooperation with the Ohio Hop Growers Guild hop quality Standards Committee.

Best Practices for Growing and Processing Hops in Ohio

Hop Quality Seal Standards Established

Objective: Achieving hop quality standards for Ohio, as hop growers, brewing customers can have confidence that Ohio hop products are safe, of good quality and produced using sound, sustainable, and efficient practices.

Standards include two levels: Mandatory (must do) and Recommended (should do)

Best Practices & Quality Seal-Holder Practices

Areas Covered: Farm Practices: Records, Irrigation, Pest Control, Crop Production, Sustainability Practices, Soil/Nutrient Management, Data Management and Sharing

Processing Practices: Harvest Timing, Cone Evaluation, Drying Requirements, Baling Requirements, Pelleting Requirements, Traceability, Labeling and Marketing

Brewers Standards: Data points expected by Brewers and customers

Educational Trainings, Licenses, and Miscellaneous Business Practices: Regional, State, National Conferences; Online self-certification through Hop Growers of America.

Standards Certification Process: Peer auditing

Standards for Growing Hops in Ohio

Farm Practices: Records, Irrigation, Pest Control, Crop Production, Sustainability Practices, Soil/Nutrient Management, Data Management and Sharing

Records: (Cross referenced with HGA Food Safety/Harvest Practices Module One, Section B, Records)

•Up-to-Date Farm Records Notebook – available on-site for inspection at will (OHGG Standards Notebook - prototype for members to duplicate and utilize for compliance.

Food Safety Modernization Act (FSMA) compliance, per HGA Module One, Section C, "Health & Human Safety Section"

•Well and/or surface irrigation water testing requirements are fulfilled and records are complete. Tested yearly for irrigation water and hand washing sink.

•Farm Insurance Policy Statement (including crop loss coverage, product coverage, property liability, accident coverage)

•Copy Pesticide License

•Spray records to meet MRL restrictions and USDA requirements are complete A maximum residue level (MRL) is the highest level of a pesticide residue that is legally tolerated in or on food

or feed when pesticides are applied correctly (Good Agricultural Practice). Label compliance and pre-harvest intervals are observed and documented.
Application information must be completed same day as the application and must be retained for seven years, per HGA training module.
•Harvesting, Drying and Baling Records are complete, to ensure traceability. Use HGA "Daily Harvest Log," attachment B5.
•HGA Grower number is assigned and utilized for traceability
•Field scouting reports,
Irrigation:
•Well and/or surface irrigation water testing requirements are fulfilled
Pest Control
•Use IPM or Organic Practices
•Scouting shall be done on a minimum Weekly Basis
•All pesticides used on Hops in Ohio Must be labelled for Ohio, check www.greenbook.com.

Standards for Growing Hops In Ohio
Crop Production
1. Worker and Food Safety – In 2010, Congress passed the Food Safety Modernization Act (FSMA), the first major overhaul of national food safety rules in more than 75 years. At the direction of Congress, in January 2013, the Food and Drug Administration (FDA) released two proposed food safety rules aimed at reducing incidences of food borne illness. The final rules for Produce Safety and Preventive Controls were released by the FDA in fall 2015. HGA Module One, Section C, Health & Human Safety Section.
•Plant Protection – Scouting for Disease, Insect, and Nutrient Imbalances which affect cone development and hop quality
•Assessing Harvest Timing – Petiole Testing and Cone Testing used to assess peak harvest time to maximize cone development. This ensures a quality chemical analysis for brewers
Sustainability Practices – Water, Soil, and Energy Conservation Practices.
•Meet with NRCS Office for a yearly assessment on farm practices and implement recommended conservation practices.
•Farms who are certified and market as Organic must be in compliance with OEFFA (Ohio Ecological Food and Farm Association) and have certification on hand
Soil/Nutrient Management
•Conduct Soil Testing and Petiole Testing, in order to apply proper amounts of chemicals, as to not leach unnecessary chemicals into the environment.
•Irrigation/Fertigation documentation
Data Management and Sharing
•"field to glass" reporting
•sharing of information with Guild members and Research Partners, field mapping, and farm management tools

•Must agree to participate in the collection an extensive amount of data on how hops are grown and processed, including field location, pests, harvest windows, conditioning, and spray applications. Recordkeeping is critical for all farms.

Standards for Growing Hops In Ohio

Processing Practices: Harvest Timing, Cone Evaluation, Drying Requirements, Baling Requirements, Pelleting Requirements, Packaging/Labeling, Traceability, and Marketing

Harvest Timing and Cone Evaluation (for fresh "wet" hop, dried whole cone hops, hop pellets)

HGA Module One, Section D, Hop Harvesting & Handling

•Harvest hops when the leaf is near 77 % moisture while still on bine. "Harvest is generally targeted when cones reach an average of 23 percent dry matter. The Oregon Hop Commission provides some limited varietal recommendations for specific dry matter targets. Growers can expect dry matter content to increase by 1 percent every four to seven days, depending on variety and environment."

It is a good practice to do a Hop Cone Chemical Analysis prior to harvest to check levels and moisture for proper harvest time. Cross check with UVM Hop Moisture Calculation and Visual/Sensory Assessment.

•Pick crop efficiently so they can be dried or delivered wet within 24 hours of cutting bine, as long as kept cool and out of sunlight. This protects quality of hop by keeping the time for degradation and oil loss to a minimum.

•Month/Day/Time of Harvest to be recorded.

Drying Requirements (for Dried Whole Cone and Hop Pellets)

•Drying shall be in a Food Safe Oast.

•Hops shall be dried using low temperature air which keeps them below 120 degrees in order to decrease degradation of the hop and retain the valuable oils.

•Moisture Content – Your hops must be dried down to between 8 – 10 % moisture and kept cool in 35 – 41 degree environment prior to pelleting.

•Upon drying, hops need to be conditioned for 24 hours, and then be kept in a 35 – 41 degree environment, either baled or vacuum packed.

•Lab Test conducted post-drying – Growers are responsible for a Chemical Analysis of their hops, so that this can be logged and labelled along with Variety, Wt. and Grower, per lot.

ASBC Methodology Hops 6-A; Hops 12, minimum.

Baling Requirements (for Dried Whole Cone and Hop Pellets)

•ODA licensed

•Compression Target

•Covering

•Storage Temperature/Light Requirements

Pelleting Requirements (for Dried Whole Cone and Hop Pellets)

•Pelleting should be done in an ODA Licensed Food Safe Room

•Proper Delivery Handling – Hops should be transported to and from processor in a way to minimize heat and breaking down of crop/oils.
•Mill to Brewing Industry Standards, T-90 Pellet Size
•During the Milling and Pelleting Process, the hops or any equipment coming in contact with the hop should remain below 140 degrees, ideally below 120 degrees.
•Lab Test – Growers are responsible for a Chemical Analysis of their hops, so that this can be logged and labelled along with Variety, Wt., Date of Harvest, Date of Pelleting, and Grower and #, per lot.
•Schedule processing time so they can receive your hops at the proper time to create the highest quality pellet for your brewer. Communication and Timing is Critical.
•As soon as the hops are pelleted, they should be cooled to 35-41 degrees and promptly packaged and labeled and placed in cool storage or deep freeze until use.

Packaging (for Dried Whole Cone and Hop Pellets)
•Packaging should be done in an ODA Licensed Food Safe Room
•Vacuum Package Pellets into moisture/light barrier Mylar Bags, with Gas Back-Flush
•Label is compliant with state law and includes
•Hops shall be stored in 35 – 41 degree cooler or deep freeze until delivery and use.
Traceability (for fresh "wet" hop, dried whole cone, hop pellets)
• Hop Product Documentation must allow for traceability of product from one supplier backward, present supplier, and one supplier forward in the supply chain. Farmer must know and document where product has been (farm records support this if you are the original grower) and where it goes after it leaves your farm or facility.

Brewers Standards for Hops Growers in Ohio
Data points expected by Brewers and customers
Best Practices:
Analytical Testing and Chemistry:
•Alpha Acids, Beta Acids, Total Oils, HSI & Total Moisture (less than 12%)
•Spray Records in compliance with ODA and other pertinent good growing practice standards/regulations, including, but not limited to state and federal guidelines.
•Stem, Leaf, Seed and Insect content noted and quantified
Record retention and availability:
•All records listed above available for brewer or customer
•Records retained for a period of 5 years, in accordance with industry standards for good documentation
•Records available for inspectors on demand
Quality Practices:
Analytical Testing and Chemistry:
•Alpha/Beta Acids: ASBC HOPS-6A
•Total Oil: ASBC HOPS-14

•HSI: ASBC HOPS-12
Moisture Content:
•Determined by ASBC HOPS-14 or equivalent
•For safety, hops must contain no more than 12% moisture. Higher moisture can lead to spontaneous combustion.

Additional Analytics:
•Stem and Leaf Debris, Seed Content, and Insect Content shall comply with American Society of Brewing Chemists (ASBC) protocols. Documented by Processing Facility.
•Spray Records in compliance with ODA and other pertinent good growing practices including, but not limited to state and federal guidelines.
•Date and Time of Harvest and Processing Traceable to end product.

Record retention and availability:
•All records listed above available for brewer or customer, traceable to lot provided
•Records available for inspectors on demand
•Report IDs traceable to product (Audited by third party)
•Records retained for a period of 5 years, in accordance with industry standards for good documentation

Standards for Growing Hops In Ohio
Educational Trainings, Licenses, and Miscellaneous Business Practices
•OSU or other University Hop Continuing Education or Conference Attendance
•Ohio Private Pesticide Applicator License holder
http://www.agri.ohio.gov/apps/odaprs/pestfert-prs-index.aspx .
•HGA Education Self-Certification
•Farm Training on Standards Requirements.
•Farm Insurance Coverage
•File Yearly USDA Crop Report
•Hop Growers Association Membership

Standards Certification Process Summary & Final Checklist
•Complete and submit an application: Application describes your farming operation.
•Initial Review: Based on the application, it is determined if your farm appears to be eligible for Seal of Quality. If so, an inspector is assigned to visit your operation.
•Inspection: An on-site inspection is conducted to verify the information in your application and evaluate how the standards have been implemented.
•Post-Inspection Review: After receive the inspector's report, a final review to determine if farm complies with standards.
•Certification Decision: If farm is compliant, an Ohio Seal of Quality can be used to package and market farm's hops.

•Yearly evaluation

A first all Ohio Hop Brew

Project partners which include brewer members of the Ohio Craft Brewers Association were supplied with cone samples for comparison with western grown hops and personal brewing evaluations. Hop cones samples were used to produce an all Ohio hops craft beer in 2015, a Russian Imperial Stout named ***Ohio Unidragon 2015*** was produced by the Clown Shoes brewing company to showcase the quality of Ohio-grown hops.

Chemical analysis

The hops harvested from the field research trials in 2015 and 2016 were analyzed for their chemical and brewing properties. This analysis was performed by a well-equipped hop analysis laboratory in Kalamazoo, Michigan, Kar laboratories (http://www.karlabs.com/hops.htm).

Table 6: Hop chemical analysis Piketon 2015

Cultivar	Alpha acids	Beta acids	Cohumulone	Colupulone
Cascade	6.42	4.62	34.30	54.80
Centennial	6.16	2.06	25.60	52.40
Columbus	12.70	3.58	28.60	56.60
Nugget	12.40	3.37	22.30	46.80
Sterling	3.37	3.48	21.80	42.90
Willamette	3.20	2.26	29.70	53.20

Table 7: Hop chemical analysis Wooster 2015

Cultivar	Alpha acids	Beta acids	Cohumulone	Colupulone
Cascade	4.98	5.23	32.80	52.00
Centennial	8.42	3.24	28.20	53.50
Columbus	15.40	3.71	27.00	54.20
Nugget	9.39	3.17	23.10	46.80
Sterling	1.50	2.09	31.00	46.40
Willamette	2.47	2.82	34.70	55.00

Table 8: Hop chemical analysis 2015

Variety	Moisture	Alpha Acids	Beta Acids	Location
Cascade	8.88	6.42	4.62	Piketon
Centennial	21.45	6.16	2.06	Piketon
Columbus	15.10	12.7	3.58	Piketon
Galena	14.42	10.5	3.82	Piketon
Nugget	8.43	12.4	3.37	Piketon
Sterling	13.19	3.37	3.48	Piketon
Willamette	12.81	3.20	2.26	Piketon
Cascade	24.31	4.98	5.23	Wooster
Centennial	16.76	8.42	3.24	Wooster

Columbus	24.50	15.4	3.71	Wooster
Nugget	16.60	9.39	3.17	Wooster
Sterling	34.83	1.50	2.09	Wooster
Willamette	17.15	2.47	2.82	Wooster

Table 9: Hop chemical analysis 2016

Variety	Moisture	Alpha Acids	Beta Acids	Location
Cascade	80.06	1.35	1.27	Bowling Green
Centennial	75.5	2.34	.74	Bowling Green
Chinook	78.16	2.5	.64	Bowling Green
Columbus	80.63	1.86	1.10	Bowling Green
Galena	77.99	1.85	.96	Bowling Green
Willamette	80.6	.86	.68	Bowling Green
Cascade	78.06	2.10	1.83	Piketon
Centennial	68.5	3.83	1.20	Piketon
Columbus	76.13	4.75	1.30	Piketon
Nugget	73.46	3.03	1.71	Piketon
Cascade	80.36	1.55	1.07	Wooster
Centennial	79.33	2.63	.95	Wooster
Nugget	76.01	2.88	.91	Wooster
Willamette	78.39	.81	1.07	Wooster

Develop an online module "Introduction to Planting and Growing Hops" to provide growers with the basic information to be successful in this growing industry.

Experts from our hop project team, University Specialists from across the Great Lakes region in partnership with the Great Lakes Hops Working Group, Industry Experts and experienced hop growers developed training modules to assist new and advanced hop farmers in learning and adopting hop production techniques. Adobe Premier Pro, an OSU approved presentation software, was used to create an online training module to sync the videos and presentation together and these are posted on the Ohio Hops web site and easily accessible to the public for viewing by growers and others interested in hop production.

These learning modules can be viewed at this link:
https://southcenters.osu.edu/horticulture/other-specialties/hops/introduction-planting-and-growing-hops-in-ohio

Provide training on all aspects of hop production through field days, annual winter workshops, and a project website.

Overall Objective: To educate farmers, landowners and Extension professionals how hops production can be an economically viable cropping option for Ohio agriculture.

Beneficiaries

Farmers, landowners, brewing businesses, and Extension Educators.

Hop Curriculum Taught and Use by Others: Since January, 2015 the hop production curriculum has been taught by the Ohio Hops Team at 52 workshops/field days to 2,780 participants throughout Ohio including; Athens, Pike, Hamilton, Wayne, Wood, Clinton, Delaware, Union, Cuyahoga and Warren counties. Additionally parts of the curriculum have been used at the Ohio State Farm Science Review.

Impact: As a result of these 52 workshops, Extension Educators have held individual consultations with participants to design business plans for hops as an alternative crop for their farm. An Ohio Hop Growers Guild Cooperative was officially formed in 2014 with the Ohio Secretary of State office. Seventy-five hop farmers are members of this Guild.

Website and social media:

A website for this project is hosted by the OSU South Centers (southcenters.osu.edu/horticulture/other-specialties/hops). This website has information regarding our workshops, field days, hop yard tours, Ohio hop production news, and photos.

We have also developed a Facebook page to spread news regarding this project (facebook.com/OhioHops). This Facebook page has 690 "likes" and some of our posts have reached over 1,500 people.

An email list-serve (sc-hops@lists.service.ohio-state.edu) is used to quickly disseminate information to everyone interested in this project. Currently, there are 844 people subscribed to the list. The list-serve has been used to advertise our field days in addition to connecting brewers with growers.

Develop a hop rhizome and plant propagation protocol that can be adopted by Ohio's nursery industry to facilitate the development of an Ohio grown hop plant propagation industry.

Specialist from the University of Minnesota Dr. Charlie Rohr, Julie Kane from Sandy Ridge Farms in Zealand Michigan and Lynn Kemme from Great Lakes Hop are breeders and propagators of hop plants. These specialists were invited into Ohio in 2015 and 2016 to teach Ohio growers of the opportunities to grow and propagate hop plants. Working with the Ohio Hops Team and the Ohio Hop Growers Guild (OHGG), production and management protocols were established and today we have Ohio plant propagation nurseries producing commercially available hop plants.

Lessons Learned

Ohio Hop Production Feasibility:

Ohio can produce local hops for the growing craft brewing industry in Ohio. These preliminary field research results show that Ohio farms are capable of producing varieties with the quality attributes demanded by the industry. Cascade, one of the most requested hop varieties, produced well in Ohio State field research studies and on farm demonstrations. There are several other varieties that may grow well throughout Ohio and are of interest to Ohio brewers.

According to the Hops Atlas (*Barth, Joh Heinrich, Klinke, Christiane, Schmidt, Claus. The Hop Atlas. Joh Barth & Sohn, Nuremberg, Germany. 1994.*) optimal conditions for growing hops from April to September are as follows:

- A latitude between 35-55 degrees
- Average temperature between 10-19ºC (50-66.2ºF)
- Average precipitation of 64 -569 mm (2.5-22.5 inches)
- Average daylight during these months between 10-19 hours per day

These findings were derived by taking the climate data for top hop growing regions in the world: George, South Africa; Tasmania and Victoria Australia; Rio Negro Argentina; Oregon and Yakima, US; Hallertau, Germany; Saaz, Czech; and Wye England. In addition, the atlas identified well drained sandy loam as the best soil for growing hops. Ohio has the following climatic and geographic conditions:

- A latitude between 38 and 41degrees
- Average daily high temperature for Columbus from April through September is above 74°F.
- Average precipitation for Columbus from April through September of 594 mm
- Average daylight for Columbus from April through September 12- 14 hours per day

Given these parameters, Ohio has all the required climatic, geographic and agronomic growing requirements to grow hops commercially. From this two year study, it has been found that the right growing and market conditions for commercial hop production do exist in Ohio and in particular Northwest Ohio.

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Project Title: OSU -- Fruit Rot of Winterberries: A New Threat to Ohio's Nursery Industry

Project Summary
Ohio's nursery crops are produced on approximately 237,000 acres, with a value of sales of about $182 million. Nearly 70% of the State production is carried out in Lake Co., which provides hundreds of jobs in local communities. Winterberry is an extremely valuable crop for nursery growers. Cut stems of the plant carrying bright red berries are popular during the holiday season and allow revenues in late fall and early winter when there is little activity and little other income for this segment of the industry. In the past few years, an unidentified fruit rot has been challenging winterberry growers in the Midwest and Eastern U.S., in some cases leading to complete crop loss. Understanding the cause of this disease, the sources of pathogen inoculum as well as the factors that favor disease development is critical to suggest proper management recommendations to growers. In this project, we monitored Winterberry plants 'Bonfire' and 'Sparkleberry' in two Ohio nurseries throughout two consecutive growing seasons to identify sources of inoculum and assess periods of tissue infection. Twigs and mummified fruit were collected during plant dormancy to determine potential sources of infectious fungal spores (primary inoculum). Flowers, leaves, and berries were collected weekly from June to November to record leaf spot and fruit rot incidence and severity, as well as pathogen recovery. Spore traps were used during the growing season to monitor spore abundance in the orchards. Studies also focused on understanding the environmental factors that favor spore release and subsequent berry infection. This information is critical to identify potential management measures, including appropriate timing for horticultural practices and fungicide treatments. Our investigations have revealed that a fungal complex, including species of *Alternaria*, *Cladosporium*, *Colletotrichum*, *Epicoccum*, *Fusarium*, *Phoma*, and *Phomopsis*, causes the disease. We have also determined that the major source of primary inoculum is the dried, mummified fruit remaining on the trees at the end of the growing season. Flowers are suspected to be entry points for fruit infection by pathogens involved in the fungal complex, which are also suspected to remain quiescent in the developing fruit until yet unidentified triggering factors induce symptom development.

Ohio's nursery crops are produced on approximately 237,000 acres, with a value of sales of about $182 million. Nearly 70% of the State production is carried out in Lake County, which provides hundreds of jobs in local communities. Deciduous hollies (*Ilex* sp.) are a valuable winter ornamental that produces a striking and persistent display of brilliant red winterberries. The plant is very popular as a cut green for use in holiday decorations and represents an important source of revenue for the Ohio nursery industry in a period of the year when business is otherwise still. Furthermore, fresh cut Winterberry harvest contributes to extended employment for regular seasonal employees.

In the past 3-4 years, a fruit rot has been challenging winterberry growers in Ohio and other states in the Midwestern and eastern U.S., in some cases leading to complete crop loss. Because the first step in any disease control endeavor is to elucidate the components of the "disease triangle" (pathogen-host-environment), this project was designed to understand the biology and epidemiology of fungal pathogens associated with the disease in order to identify appropriate, well-timed, cost effective management strategies to prevent/control it. The specific objectives of this project were to:

1. Identify the disease-causing pathogen(s), determine their seasonal spore abundance and the environmental factors that favor spore release and infections;
2. Determine pathogenicity of the different isolates.

By providing nursery growers with research-based guidelines to combat this disease, this project aimed to directly improve profitability in this segment of the industry.

Project Approach

OBJECTIVE 1. Identify the disease-causing pathogen(s), determine the seasonal spore abundance and the environmental factors that favor spore release and subsequent fruit infection.

Based on preliminary observations carried out by the OSU Plant & Pest Diagnostic clinic in the winter of 2013 and a spore trapping trial carried out in 2014, several fungal species were suspected to be involved in this disease. However, it was unknown when in the growing season infection occurred as well as the role of each of these fungal species in disease development. Therefore, determination of infection at different time points throughout the growing season, correlation of infection with the seasonal spore abundance, along with an assessment of disease incidence and severity, were considered critical to understand the disease and determine the role of each pathogen.

To this extent, two field trials were established in commercial nurseries located in Lake Co., OH during the 2015 and 2016 growing seasons. A third trial was added in 2016 in an unmanaged orchard in Wayne Co., OH. Two different cultivars, 'Sparkleberry' at Nursery B, and 'Bonfire' at Nursery A and C, were selected for the study based on the observed susceptibility to the disease. On April 1st of each year, the day of trial establishment, twigs carrying mummified fruit from the previous growing season were collected from the two nurseries and brought to the laboratory to assess the presence of overwintering fungal inoculum through direct isolation on microbiological media. Buds, bark and xylem tissues were processed separately. Cultures were then purified and subjected to morphological and molecular (selected isolates only) identification. Counts of infected tissues for each pathogen recovered were analyzed using the 2xc contingency table and mean comparison was done using the Chi-square goodness of fit test in SAS statistical software v. 9.4 (SAS Institute, Inc., Cary, NC).

Also on April 1st and weekly thereafter until November 30th of each year, spore-traps made of microscope glass slides coated with petroleum jelly were hung within the trees, allowed to trap spores weekly, and then individually collected in sterile 50-ml screw-cap tubes and transported to the laboratory. Spores were removed from the traps by adding 10 ml of sterile distilled water into the screw-cap tube and then shaking by hand for 60 s. Two aliquots of 200 µl each were collected per spore trap and spread onto two replicate Petri plates containing microbiological media amended with antibiotics. Plates were incubated at room temperature and the number of developing fungal colonies was counted for up to 3 weeks. Fungal isolates were sub-cultured to ensure purity and subjected to morphological identification. Weekly records of total precipitation and average temperature were downloaded from the weather network available in the County. Weekly weather data values were obtained by the sum of daily precipitation and by averaging daily mean temperatures. Correlation analysis was performed to examine the relationship between weekly total numbers of spores of each pathogen, and the environmental variables recorded on the same week at each location, by using PROC CORR in SAS.

Samples of flowers, leaves and fruit were also collected at regular intervals (1-2 weeks) as they became available throughout the growing season to assess frequency of infection by the different pathogens and to monitor disease incidence (expressed as % of samples with symptoms) and severity (expressed as % of sample area with symptoms) over time. Flowers were collected at the flower bud and full bloom stages in June of each year, whereas leaves and fruit were collected from June through November. On each collection date, 100 sample units were picked randomly within the orchards and brought to the laboratory to retrieve the fungal pathogens. Plant tissues were surface disinfected by immersion in 0.5% bleach solution for 90 seconds (flowers), 2% bleach solution and 48% ethanol solution for 30 seconds each (leaves), or 2% bleach solution for 2 minutes (fruit), followed in all cases by three rinses in sterile distilled water. Following disinfection, tissues were plated on V8 agar medium to retrieve the fungal pathogens. As far as leaf samples are concerned, leaves were inspected for symptomatic lesions and isolations were attempted from the margin of the lesion. As far as fruit samples are concerned, they were first sorted into two categories: symptomatic and asymptomatic. Symptomatic fruit were subjected to isolation from the margin of the lesion, while asymptomatic fruit was cut in half and both halves plated face down on V8 medium. All plates were incubated at room temperature on a laboratory bench under fluorescent light and monitored for any fungal growth for up to 3 weeks. Cultures were then sub-cultured and purified and subjected to morphological and molecular (selected isolates only) identification. The frequency of recovery of each pathogen from the different plant tissues was analyzed using the 2xc contingency table and mean comparison was done using the Chi-square goodness of fit test in SAS. Correlation analysis was performed to examine the relationship between weekly disease incidence and severity and the environmental variables recorded on the same week at each location, by using PROC CORR in SAS.

OBJECTIVE 2. Determine pathogenicity of the fungal isolates on winterberry tissues.
A selected number of fungal isolates recovered from symptomatic tissues during the 2015 field season, including the species *Alternaria alternata, Colletotrichum acutatum, Diaporthe cf. heveae* and *Epicoccum nigrum*, were tested for pathogenicity on leaves, flowers, and fruit of container-grown Winterberry plants 'Sparkleberry' maintained at the Waterman Farms facility in Columbus, OH during the spring and summer of 2016. Pathogenicity on leaves was evaluated through detached leaf bioassays in the laboratory, while pathogenicity on flowers/fruit was assessed through inoculation of whole plants maintained outdoor in a container nursery area.

Leaves were detached from the plants, brought to the laboratory and subjected to surface disinfection as described above. Pathogenicity of the different isolates was tested by spraying a suspension of $1x10^5$ spores ml^{-1} in 0.05% v/v Tween 20 solution on the surface of wounded or unwounded leaves. Control leaves received sterile aqueous 0.05% v/v Tween 20 solution. Eight single leaf replicates per pathogen were arranged on a plastic tray in a completely randomized design. The whole tray was then enclosed in a clear plastic bag to provide a humid environment for infection to occur and placed under fluorescent light. Lesion development was recorded up to 2 weeks post-inoculation and successful re-isolation of the pathogen(s) from symptomatic tissue served as proof of pathogenicity. The experiment was repeated twice.

Fruit was inoculated at five different stages of development: flower bud, early bloom (flower stage), immature green fruit (petal fall stage), mature green fruit, and mature red fruit. At each stage, every flower bud, flower or fruit on every plant was individually inoculated by placing a 6 or

12 µl drop from a spore suspension of $1x10^5$ spores ml^{-1} in 0.05% v/v Tween 20 solution using a micropipette. Following inoculation, the whole plant was enclosed in a plastic bag for 24 hours to favor infection. Control plants received sterile aqueous 0.05% v/v Tween 20 solution and were also covered with a bag. Plants in the nursery area were arranged in a complete randomized block design with six blocks. Symptoms development was recorded starting November 8, 2016. Successful re-isolation of the pathogen(s) from symptomatic tissue served as proof of pathogenicity.

Goals & Outcomes Achieved

OBJECTIVE 1. Identify the disease-causing pathogen(s), determine the seasonal spore abundance and the environmental factors that favor spore release and subsequent fruit infection.

In winter of 2013, at the time of branch harvest, fruit samples of three different cultivars of Winterberry from three different Ohio nurseries were sent to the C. Wayne Ellett Plant and Pest Diagnostic Clinic for diagnosis. *Colletotrichum* sp., *Botryosphaeria* sp., *Phomopsis* sp. and *Alternaria* sp. were isolated from the rotten fruit. It is to be noted that these are all potential fruit rot pathogens and widely studied on different crops such as strawberry, blueberry, and apple. At the time this project was started, no official record on the occurrence of these pathogens on winterberry fruit and their role as the disease causing agents was available.

Winterberry holly is a perennial plant, which means that its stems, leaves or fruit, could be the overwintering sites for pathogens to survive. In the case of deciduous plants, fungi usually overwinter as mycelium or spores in leaves or fruit left in the field, as well as in bud scales. These will serve as the primary inoculum to initiate infection when the new season starts. One of the most effective disease management strategies is to reduce the amount of primary inoculum in the field. Thus, understanding where pathogens overwinter is crucial to establish effective management practices. Two years of data collected from three trial locations (Nursery A and B in 2015, and Nursery A, B and C in 2016) has suggested that the disease is caused by a fungal complex rather than by a single pathogen. The complex mainly includes the species *Alternaria alternata*, *Cladosporium* sp., *Colletotrichum acutatum*, *Diaporthe cf. heveae* (*Phomopsis), Epicoccum nigrum*, and *Phoma* sp. Additional pathogens that may have a yet undetermined role in the disease include *Botryosphaeria* sp. and *Fusarium* sp. Overwintering inoculum of all these pathogens was indeed consistently recovered from the mummified fruit remaining on un-harvested stems at the end of the growing season, as well as from the buds and the bark of dormant twigs (Fig. 1). The relative abundance of the different pathogens on dormant plant material at the three locations slightly differed, with the unmanaged nursery (Nursery C) showing higher recovery compared to the two commercial nurseries (Fig. 1). To be noted that in 2016 no mummified fruit was present in nursery A and B due to birds' activity. Thus, data from this plant tissue are missing from the corresponding charts (Fig. 1). Nonetheless, we can confidently say that the major source of infectious fungal spores that may start the disease cycle (primary inoculum) is the dried, mummified fruit remaining on the trees at the end of the growing season.

Sometimes, pathogens can infect plant tissues and remain inactive for a variable period of time. This is called latent infection. Therefore, in this project we considered very important to monitor infection in the fruit since the early stages of tissue development (flower stage). As observed in the dormant plant material, the species *Alternaria alternata*, *Cladosporium sp.*, *Epicoccum nigrum*, and *Phoma* sp. were again consistently recovered at the three locations from flower tissues, and an increase in their abundance was observed as the flower development progressed from the bud stage

to full bloom (Fig. 2). *Diaporthe cf. heveae* (*Phomopsis*) and *Botryosphaeria sp.* were also recovered from flower tissues, mainly in Nursery C. It is important to remember that winterberry is a dioecious plant and that the activity of insect pollinators is highly important for flower fecundation. Our observations contribute to the hypothesis that bloom may be a critical moment for these pathogens to enter the still undeveloped fruit.

The year before this project was initiated (2014), growers had lost their entire crop to the disease. However, in the two seasons included in this study, the level of disease incidence observed on the fruit at the two commercial nurseries was very low, reaching its maximum of 5% in nursery B in 2015 (Fig. 3). We believe that this phenomenon is due to a combination of factors: (1) extensive literature in similar pathosystems supports the hypothesis that cold temperatures are partially responsible for triggering symptoms development in latently infected fruit. Indeed, the level of disease incidence and the temperature values recorded at each location in the two years of the study were negatively correlated (Table 1). The exceptionally warm temperatures recorded in 2015 may thus have negatively impacted symptoms development. (2) Since we timely shared the results of our findings with growers directly involved in the project, we may have suffered the consequences of them implementing some control strategies, including removal of the mummified fruit from the trees at the end of 2014, which consequently may have impacted the amount of primary inoculum available in the field to initiate the epidemic in 2015. Similarly, at the end of the 2015 growing season, birds' activity resulted in no un-harvested fruit remaining on the trees over the winter; thus, a lower amount of primary inoculum was available that could have triggered the disease epidemic in 2016. (3) Finally, throughout 2015 and 2016, growers implemented fungicide rotations in part of their orchards, which may have impacted our study in multiple ways: less overall inoculum available in the orchard during the season, and potential fungicide drift from treated to untreated plots. Indeed, the level of disease incidence that was recorded in the unmanaged and thus "undisturbed" nursery in 2016 (nursery C), reached approximately 30% incidence (Fig. 3). Even though disease incidence and severity were low, the pathogen recovered from the symptomatic lesions included *Alternaria alternata, Colletotrichum acutatum, Diaporthe cf. heveae* and *Epicoccum nigrum*, which confirms previous observations (Fig. 4).

As previously stated, we monitored symptoms development and disease progression but also the relative abundance of fungal pathogens in the non-symptomatic fruit to account for possible latent infections. Interestingly, all the pathogens recovered from the flowers and the symptomatic fruit were also present in the asymptomatic fruit, with *Alternaria alternata, Cladosporium sp.* and *Epicoccum nigrum* being the most prevalent (Fig. 5). In all cases, fungal growth from asymptomatic fruit observed on the plates occurred from the corresponding positions of calyx and stigma on the flower. This observation contributes to reinforcing the hypothesis that flowering may be a critical moment for these pathogens to enter the fruit and initiate latent infections.

Many of the pathogens involved in this disease complex can potentially infect leaves and cause leaf spots. On these lesions, pathogens can produce more spores, which may serve as a secondary source of inoculum to infect fruit during the season. On both years, leaf spot incidence and severity at the three nurseries increased progressively overtime, ranging between 65-100% incidence, and 15-35% severity (Fig. 6). As observed for the fruit data, disease incidence on leaves recorded at each location in the two years of the study was again negatively correlated with temperature (Table 2). The relative abundance of the different pathogens recovered from the leaf spots at the three

locations was comparable, with *Alternaria alternata, Colletotrichum acutatum, Diaporthe cf. heveae* (*Phomopsis*), and *Epicoccum nigrum* being the most prevalent (Fig. 7).

Spores of *Phoma sp., Cladosporium sp*., and *Fusarium sp.,* were also consistently recovered from the spore traps at the three trial locations throughout the two growing seasons. *Alternaria sp., Colletotrichum sp.,* and *Epicoccum* sp. were also recovered, although to a lower extent (Fig. 8). Analysis of the weekly spore concentrations and weekly average of corresponding environmental factors pooled across years and locations revealed a positive correlation of *Alternaria* and *Fusarium* spore counts with precipitation.

OBJECTIVE 2. Determine pathogenicity of the fungal isolates on winterberry tissues.
In plant pathology, fulfillment of Koch's postulates is an essential step to prove that an organism isolated from diseased samples is actually responsible for the disease. For this reason, in 2016 we tested the ability of a representative number of fungal isolates, including the species *Alternaria alternata, Colletotrichum acutatum, Diaporthe cf. heveae* and *Epicoccum nigrum* recovered from symptomatic tissues during the 2015 field season, to cause disease on leaves and fruit of Winterberry 'Sparkleberry'. Both kinds of tissues were inoculated with the pathogen in the presence or absence of a wound with the purpose of demonstrating if the specific pathogen was able to penetrate the plant tissue directly or it needed an artificial point of entry. This information may be useful to predict if injuring factors such as insect or bird activity, as well as hail, may impact the health of the berries.

All the isolates inoculated on leaves were able to cause leaf spots regardless of the presence of a wound on the leaf surface. As far as fruit is concerned, all pathogens inoculated on wounded mature red fruit were able to cause fruit rot. However, only *Diaporthe cf. heveae* was able to cause disease on unwounded fruit that had been inoculated at flower and petal fall stages of fruit development. In all cases, successful re-isolation of the inoculated pathogen from the lesions fulfilled Koch's postulates.

Throughout the duration of this project we have carried out several outreach activities to timely communicate our findings to industry stakeholders as well as the scientific community. A detailed list of these activities is provided below:

<u>Webinars:</u>

- February 2016. Winterberry Fruit Rot research update. The Ohio State University developed and delivered a 1-hour presentation to nursery growers to provide an update on ongoing research on fruit rot disease of Winterberry holly. There were 10 participants on the webinar.
- September 2015. Winterberry Fruit Rot research update. The Ohio State University developed and delivered a 1-hour presentation to nursery growers to provide an update on ongoing research on fruit rot disease of Winterberry holly. There were 10 participants on the webinar.
- March 2015. Biology, Epidemiology and Control of Fungal Pathogens Associated with fruit Rot of Winterberry Hollies in Ohio Nurseries. The Ohio State University developed and delivered a 1-hour presentation to nursery growers in Ohio, Pennsylvania and Maryland to provide an update on ongoing research on fruit rot disease of Winterberry holly. There were 10 participants on the webinar.

<u>Oral Presentations:</u>

- August 2016. Identifying sources of inoculum and timing of tissue infection by fungal pathogens associated with winterberry fruit rot. The American Phytopathological Society Annual Meeting, Tampa, FL where 130 attendees were present.
- July 2016. New and problematic nursery diseases. AmerivanHort Cultivate'16, Columbus, OH had 150 attendees.
- February 2016. Identification and management of important and emerging diseases of trees and shrubs in nurseries. Tri-State Green Industry Conference, Cincinnati, OH where 200 attendees were addressed.

Poster Presentations:

- Lin, S, Taylor, NJ, Zondag, RH, Peduto Hand, F. 2015. "Understanding the emergent fruit rot disease of Winterberry holly." The American Phytopathological Society Annual Meeting, Pasadena, CA August 2015, reached 300 attendees.
- Lin, S, Taylor, NJ, Zondag, RH, Peduto Hand, F. 2014. "Fruit rot of Winterberries: A new Threat to Ohio's Nursery Industry." OSU Annual Conference and Research Colloquium, Columbus, OH, December 2014, where 80 participants were reached.

Beneficiaries

Winterberries are an extremely valuable crop for nursery growers and one that contributes to extend employment for regular seasonal employees. As a result of this disease problem, Ohio nursery growers have suffered a severe reduction of income from this crop for several years. Because the first step in any disease control endeavor is to elucidate the components of the "disease triangle" (pathogen-host-environment), this project aimed to gather all the information necessary to design appropriate disease management strategies. By providing nursery growers with research-based guidelines to combat this disease, this project aimed to directly improve profitability in this segment of the industry. While there are still important aspects of this disease that needs to be further investigated, timely communication of our findings to nursery stakeholders in Ohio and other winterberry-producing states has allowed for some cultural control measures to be implemented (i.e. removal of overwintering mummified fruit), which, in combination with other factors, may have diminished the amount of disease in the field. Growers directly involved in this project reported that their yearly income from sales from this crop went from an average of $22,100 in 2013-2014 (prior to project initiation), to an average of $37,960 in 2015-2016 (years included in this project).

In summary, through this project we have:

- Identified the disease-causing agents and revealed that the disease is caused by a fungal complex rather than by a single pathogen as initially thought. The complex mainly includes the species *Alternaria alternata, Cladosporium sp., Colletotrichum acutatum, Diaporthe cf. heveae* (*Phomopsis*), *Epicoccum nigrum*, and *Phoma* sp. Additional pathogens that may have a yet undetermined role in the disease include *Botryosphaeria sp.* and *Fusarium sp.*
- Determined that the major source of infectious fungal spores that starts the disease cycle (primary inoculum) is the dried, mummified fruit remaining on the trees at the end of the growing season.
- Identified flowers as potential entry points for fruit infections by pathogens involved in the fungal complex, which are also suspected to remain quiescent in the developing fruit until yet undetermined triggering factors induce symptoms development.

- Proved pathogenicity of the main pathogens involved in the fungal complex on both leaves and fruit tissues.
- Communicated our findings to stakeholders and the scientific community in a timely manner allowing for preventive measures to be taken to reduce, but not yet fully control, the disease epidemic.

Lessons Learned

While important and necessary, conducting on-farm research has certainly been challenging to the extent of maintaining standardized conditions from one season to the next. Since we timely shared the results of our findings with growers directly involved in the project, we also suffered the consequences when they implemented the control strategies that emerged from early research. For this reason, we retained necessary adding a third trial location in an undisturbed environment in the second year of the project, which increased our workload. In future research, establishment of a container nursery at the OSU research farm will allow for close control of the experimental variables without being influenced by growers' standard growing practices, both within their winterberry orchards and from normal nursery production activities surrounding the growers' orchards. This will allow for a more close control of the variables of the experiments and consequent improved research performance.

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Project Title: OSU -- Agricultural Water Quality and Testing: Connecting Produce Growers with Ohio Water Testing Laboratories

Project Summary

Food safety of fresh produce remains a public health concern. The Ohio State University Fruit and Vegetable Safety Team (OSU FVST) is responsible for training Ohio produce growers on Good Agricultural Practices (GAPs) that pertain to on-farm food safety standards proposed within the Food Safety Modernization Act (FSMA) produce safety rule. Testing and utilization of water during pre-harvest and post-harvest production is a FSMA standard that produce growers repeatedly raise questions about during GAPs classes and discussions. The vast majority of Ohio growers do not currently test their water. The estimated 2500 produce growers in the state use several water sources for a wide range of agricultural purposes. To comply with the FSMA produce safety rule, virtually every grower in Ohio must become aware of their water quality and establish a water testing protocol on their farm. In this project we 1) developed and deliver the Agricultural Water Quality and Testing workshop that will enhance growers' understanding of the requirements for water quality, proper water sampling techniques and the available resources for testing, and 2) actively connected fruit and vegetable farmers with water testing laboratories. The new FDA regulations require regular testing for water used during pre-harvest and post-harvest activities on produce farms. Although Ohio growers are required to comply with the Rule, the majority was not testing their agricultural water. While a number of the growers is exempt from the Rule, the buyers expect growers to abide by FDA guidelines regardless of their official status.

Also, the exemption is pertinent to the absence of any food safety issues coming from their farm. Cost and the lack of understanding that surrounds proper testing procedures and water laboratories were perceived barriers to water testing implementation are. In this project, OSU FVST addressed this gap in knowledge and prepared 350 growers for regulatory requirements effective as of Jan 2016. We have developed Agricultural Water Quality Workshops and delivered the training to 350 growers in six regional workshops.

We facilitated the conversation and the establishment of relationship between participating growers and commercial lab representative and rowers that participated in the laboratory. The growers received discounts for water testing in participating commercial labs. Education gave the participants of workshops an advantage in the market and enhanced their competitiveness.

Project Approach

In two years of the 2014 Specialty Crop Block Grant, the Ohio State University's Fruit and Vegetable Safety Team taught 350 (267 in 2016) produce growers about Agricultural Water Quality and testing practices at six different 'water workshops' in Huron, Wayne, Piketon, Mt. Hope and at the Mid-Ohio Grower Meetings. Each workshop was approximately three hours long; one hour dedicated to the science behind water quality, one hour dedicated to the proposed standards in the FDA Food Safety Modernization Act (FSMA) Produce Safety Rule, and one hour dedicated to proper water sample collection and laboratory analysis. Workshops were held during January, March and April of 2015 and 2016. Each attendee received a packet containing handouts on water sample collection and handling techniques, pre-harvest and post-harvest decision trees and a 50% discount voucher redeemable at one of the participating laboratories. Growers who attended workshops in Wooster, Piketon, Mt. Hope and Mid-Ohio Growers meeting were given the opportunity to complete a pre-test and post-test. We have developed and conducted pre and post-workshop knowledge surveys. The average pre-test score was 61.5% and the average post-test score was 81.9%. We have increased post-test knowledge scores to 87.09% in the second year. The follow up surveys to assess the retention rate in water testing is scheduled for 12 months after the original survey. Water quality issues at a local produce operation were investigated. A participating laboratory helped collect and process 25 farm's water samples. Results are utilized by the team to prepare the realistic calculation examples for the growers and real-life scenarios during future Water Quality and GAP and other produce safety training.

Goals and Outcomes Achieved

The Ohio State University Fruit and Vegetable Safety Team developed an educational workshop on Agricultural Water Quality and Testing. The workshop targets Ohio fruit and vegetable growers. Information on the final Food Safety Modernization Act (FSMA) Produce Safety Rule for microbial water quality, and proper sampling design and techniques is covered. Under the FSMA produce safety rule, Ohio growers are required to follow a set of agricultural water standards that entail regular testing and risk assessment.

The Agricultural Water Quality and Testing workshop consists of three modules. In the first module, the Ohio State University Cooperative Extension Educators and Food Safety State Specialist give growers an overview on the FSMA produce safety rule and the agricultural water standards and requirements within the rule. Regular microbiological water testing, monitoring of the quantifiable measurements of human pathogen indicators (i.e. -- total coliforms and generic *Escherichia coli*), and risk assessment will be covered.

The second module is presented by participating water laboratory personnel and contains: the science behind processing laboratory samples, fundamentals regarding the "what and where" of sample collection, sampling design customized to participants' specific operations, and detailed explanations of adequate sample collection methodologies that enable cost savings (i.e. – self collection of water samples *vs.* having a laboratory employee collect samples on the farm, usage of convenient sample drop-off locations to reduce the cost of sample preservation and shipping, etc.). The final module includes water sample collection overview delivered by the OSU personnel and hands-on demonstrations of sampling techniques delivered by laboratory experts. A number of hands-on activities are included. The sample collection tools are presented. Growers learn how to use sterile water sample bottles, how to prevent sample contamination by human error, the importance of temperature maintenance, and about proper shipping and handling of samples. Education of growers in these three segments gives the participants confidence in their own ability to adequately comply with FDA regulations and buyer expectations. Scores from pre and post-test surveys distributed to participant show significant increase in knowledge to 87% after the workshop.

Our original goal was to train 400 growers, to date we educated 347 participants. Unforeseen delays, such as often updates to materials due to the finalization of the Rule and loss of the project coordinator contributed to the delay. However, additional workshop is scheduled for Feb 2017 where we expect 50+ participants. Ohio growers have not previously had access to such education; therefore, data does not exist on success rates of educational water testing workshops. Our anticipated achievement level was that 30% of the growers will continue to test their agricultural water after the initial subsidized water test. We will be able to collect this data in 2017 as a follow-up questionnaire will be distributed approximately 9-12 months after the workshops takes place.

Beneficiaries

We trained 350 Ohio fresh produce growers over two years in Agricultural Water Quality and Testing. The workshop is available on an 'as-needed basis'. Four extension educators are trained in delivering the classes. One workshop is already scheduled for Feb 2017. After attending a workshop and performing necessary water tests, growers gained skills required to develop their own water-testing plan. These skills will contribute to increase in grower's self-efficacy to meet the regulation. These skills allow the growers to expand their markets to buyers who already require water testing, thus creating a potential for increased profits. In addition, water-testing laboratories have experience increased demand, and the possibility of more jobs in laboratory sector as well as possible lower testing costs, quicker processing times and faster results to gain insight on their water quality.

Lessons Learned

Our original goal was to train 400 growers, to date we educated 347 participants. Unforeseen delays, such as often updates to materials due to the finalization of the Rule and loss of the project coordinator contributed to the delay. Additionally, in year one two items that might have contributed to lower attendance numbers were the length of the class and the fact that the class was not as well-known as other produce safety classes delivered in the state. We have worked to address this/ Additional workshop is scheduled for Feb 2017 where we expect 50+ participants. Ohio growers have not previously had access to such education; therefore, data does not exist on success rates of educational water testing workshops. Our anticipated achievement level was that

30% of the growers will continue to test their agricultural water after the initial subsidized water test. We will be able to collect this data only in 2017 as a follow-up questionnaire will be distributed approximately 12 months after the workshops takes place.

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Project Title: OSU -- Validation of waiting intervals for the incorporation of untreated biological soil amendments into soil where specialty crops are grown in Ohio

Project Summary

The production of a safe and wholesome produce is a priority for Ohio specialty crop farmers. In order to remain competitive, this goal must be achieved within the emerging regulatory framework, notably the Food Safety Modernization Act (FSMA). Incorporation of animal manure into the soil is an important source of nutrients and a manner to dispose of animal waste. FSMA had initially proposed establishing the permissible interval between the application of untreated manure to fields and harvest at 270 days which would have had a detrimental effect on the management practices of small farm operations. The results of this project validated that a wait period of 90-120 days between the application of untreated manure and the harvest of cantaloupe would place fresh produce at the same level of food safety risk for pathogens as that of 270 days.

Project Approach

The risks associated with the use of untreated soil amendments of animal origin (bovine manure) as a function of time of soil application were assessed. Both years (two production cycles) followed the same protocol and included the same three producer cooperators. Dairy heifer manure secured from one location was applied to all three farms, on specified blocks at 270, 180, 120 and 90 days prior to expected harvest of cantaloupes. Total coliforms and *E. coli* counts and pathogen (*Listeria, Salmonella, E. coli* O157 and *Campylobacter*) presence was assayed monthly in soils and weekly on harvested melons from the three cooperator farms.

The combined data from both years can be viewed on the attached graphs. *E. coli* counts declined over time, and approached baseline levels after approximately 90 days. Pathogens were detected sporadically from soils and from melons, both from amended and control (non-amended) plots at similar frequencies. Waiting more than three months after manure application did not statistically reduce the likelihood of pathogen detection or the total *E. coli* counts in the soil, notwithstanding, the detection of the pathogens on melons (grown on plastic) at harvest, even in un-amended plots, raises concern about the sources of pathogens on melons.

Microbiological sequencing of the soil and manure DNA has been performed and microbiological profile analysis is in process. Upon completion, microbiological profiles will be compared between the manure, the amended and non-amended soils. DNA could not be generated from the cantaloupe wash-ate so these will not be included in the comparisons.

Project Summary

This was the second year of a two year trial to determine the risks associated with the use of untreated soil amendments of animal origin (bovine manure) on melons as a function of time of soil application. This year's trial followed the same protocol and included the same producer cooperators as the first year, with the only experimental difference being the plot locations on the farms. Dairy heifer manure secured from one location was applied to all three farms, on specified blocks at 270, 180, 120 and 90 days prior to expected harvest of cantaloupes. Total coliforms and *E. coli* counts and pathogen (*Listeria, Salmonella, E. coli* O157 and *Campylobacter*) presence was assayed monthly in soils and on melons at harvest from the three cooperator farms.

Results from the second year trial, followed suit with the results determined in the first year and the combined data from both years can be viewed on the attached graphs. *E. coli* counts declined over time, and approached baseline levels after approximately 90 days. Pathogens were detected sporadically from soils and from melons, both from amended and control (non-amended) plots at similar frequencies. Waiting more than three months after manure application did not statistically reduce the likelihood of pathogen detection or the total *E. coli* counts in the soil, notwithstanding, the detection of the pathogens on melons (grown on plastic) at harvest, even in un-amended plots, raises concern about the sources of pathogens on melons. Microbiological sequencing of the soil and manure DNA has been performed and microbiological profile analysis is in process. Upon completion, microbiological profiles will be compared between the manure, the amended and non-amended soils. DNA could not be generated from the cantaloupe wash-ate so these will not be included in the comparisons.

Project Approach

The production of a safe and wholesome produce is a priority for Ohio specialty crop farmers. In order to remain competitive, this goal must be achieved within the emerging regulatory framework, notably the Food Safety Modernization Act (FSMA). Incorporation of animal manure into the soil is an important source of nutrients and a manner to dispose of animal waste. At the commencement of this project, FSMA had proposed increasing the permissible interval between the application of untreated manure to fields and harvest, to 270 days. The hypothesis of this project was that increasing the interval from 120 to 270 days does not significantly improve food safety under conditions typical of small-scale Ohio specialty crop producers.

Goals and Outcomes Achieved

This study provides data from two consecutive years of research concerning the survival of bacteria and specific pathogens in Ohio specialty crop soils. This data has been shared with the Food and Drug Administration as they determine the final regulations established through the Food Safety Modernization Act. Presently in relation to the use of untreated soil amendments to soils used for produce production, FSMA states that, "At this time, the FDA does not object to farmers complying with the USDA's National Organic Program standards, which call for a 120 day interval

between the application of the raw manure for crops in contact with the soil and 90 days for crops not in contact with the soil." This final regulation is quite different than the original 270 days!

Presently, work is taking place to finalize data analysis and publish the study. The outcome of the work was disseminated at several avenues to different target audiences including two Amish community "crop walk" presentations, two presentations to the Mid-Ohio Growers Association, three presentations to the Ohio Produce Growers and Marketers Association and one presentation at the International Association for Food Protection. Several question and answer meetings with the cooperating producers have also transpired throughout the project as well as at its conclusion. It's also very clear that dissemination of information has taken place among the Amish community as on numerous occasions we have had impromptu opportunities to discuss our findings with interested individuals.

Information has been openly shared at multiple venues so informal conversations surrounding the study have easily transpired. Considering also that the final FSMA regulations concerning this matter align very similarly with our findings, stakeholders are not being required to consider alternatives as the time frames determined to be most beneficial are already in place.

Beneficiaries

In addition to the changes established with FSMA, this project is of particular importance as it provides small scale Ohio farms real data on which they can base their management practices related to manure application on their local commercial farms. Ultimately both farmers and consumers benefit as we now have a better understanding of management practices that can have a direct effect on the food safety risks involved with produce production.

Attendance at community "crop walks" averaged 150. Mid-Ohio Grower meetings averaged 150-200 and the Ohio Producer Grower and Marketers Assn another 100 per meeting. It's hard to estimate the "ripple effect" of our numerous conversations throughout the Amish community but evidence of continued discussion continues to surface. Interest and cooperation in new and evolving research projects is also an indication of the appreciation for past research efforts and outreach.

Lessons Learned

Stakeholder-driven participatory research provides an excellent avenue for community interaction and education. This project was initiated based on Ohio farmers need for information. Although research on commercial farms which utilizes farmer participation may decrease the control over experimental conditions and how tasks were performed, these drawbacks are far outweighed by the benefit of having the outcomes better reflect how things actually happen in the field. Moreover, the continued community engagement has generated widespread interest and communication within the target population and natural peer-to-peer dissemination of information is highly effective.

As with most research, one question was answered (waiting interval required to reduce risk to baseline), but other questions arose. Specifically, the source and route of contamination of the melons at harvest remains enigmatic.

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Project Title: OSU -- Cultivar Evaluation, Expansion, Season Extension and Grower

Project Summary

Super berries, such as *Aronia*, blackberries, blueberries, Chinese goji berries, elderberries, raspberries, are very popular fruits because of their health benefits. Our research and extension efforts on super berries from 2014 to 2016 have reached more than 780 growers through county, regional and state workshops and 680 people through research tours of super berry plots at OSU South Centers in Piketon. We achieved our goal of publishing at least eight press releases about super berries during the two years of this grant. These press releases were sent to numerous news outlets in Ohio and beyond. These articles reached at least 250,000 consumers in Ohio during the 2-year grant period. Three fact sheets have been written and three videos have been posted online. The project goal of adding at least 30 acres of existing super berries, such as blackberries, blueberries, and raspberries from 2014 to 2016 has been achieved based on our interviews with growers and county extension educators. At least 20 growers planted new super berries. It is estimated that at least 10 acres of new super berries, such as *Aronia* berries, elderberries and Chinese goji berries, were planted in Ohio from 2014 and 2016.

Two new cultivars of *Aronia* and elderberries have been identified. One good cultivar of goji berry has been identified and one potentially good cultivar has been selected for further evaluation. Detailed anthocyanin (antioxidant) profiles of 5 elderberry cultivars and one blueberry cultivar have been identified. These results laid ground work for more comprehensive studies of antioxidants in the future. Our project has helped Ohio retain and create jobs in the specialty crop production sector. The blackberry production system using winter protection with rotatable cross trellis has helped Ohio retain 30 to 50 jobs. Most of the new super berries (*Aronia* and elderberries, and goji berries) were harvested and used in value added products, such

as pies, jams, jellies, salsa and wine. It is estimated that added acreage of new and existing super berries helped growers generate 20 new jobs in Ohio from 2014 to 2016.

The concept of super berries has been gaining popularity among consumers and growers. New super berries, such as *Aronia* berries, elderberries, and goji berries, presented a unique opportunity for new and existing growers. These berries are high in antioxidant content and can be successfully grown in Ohio based on our observations, limited experience of growers, and successes in our neighboring states. The elderberry acreage in Missouri went from 0 to 127 in 14 years while the *Aronia* acreage in Iowa went from 0 to more than 500 acres in a similar period. Chinese goji berries are being sold by more nurseries in the U.S. and can be a niche market crop. There was a strong demand for information on best management practices, season extension methods, and innovation production systems of blueberries, brambles, *Ribes* (currants and gooseberries), as well as new super berries. Established research plots and knowledge gained from the past SCBG projects were used to help growers improve their production and marketing skills. This proposed project was not submitted to another Federal or State granting agencies.

The established blueberry and *Ribes* demonstration plots at OSU South Centers were funded by previous SCBG grants. The brambles plots were funded by a SCBG grant, which ended in 2014. This project did not enhance the competitiveness of non-specialty crops. The project funds were managed by the Office of Sponsored Programs at The Ohio State University.

Project Approach

1. Research Projects:

1.1: Research Plot Installation and Fruit Harvests: Our research crew prepared soils for several test plots of elderberries, Aronia berries and Chinese goji berries at OSU South Centers in 2014. Our research assistant Ryan Slaughter traveled to Missouri in March 2015 to gather production and marketing information on elderberry production there. He met with Mr. Patrick Byers of the University of Missouri and several growers there. We collected some production information on commercial production of super berries from Missouri and Iowa. Ryan Slaughter brought back cuttings of superior elderberry selections and cultivars for propagation. Field planting of Aronia, elderberries, Chinese goji berries, and honeyberries was completed in April and May in 2015. Bird netting was installed in the elderberry plot in July, 2015 and reapplied in July 2016. Fruit harvest, plot maintenance, and measurements of fruit color were conducted from May to September, 2015 and 2016. Since we have a very diverse group of fruits, fruit harvest took place from June to September, and continued in October, 2015 and 2016. Fruits were harvested, weighed, graded, and stored in a freezer and were later analyzed in both 2015 and 2016.

1.2: Fruit Antioxidant (including Anthocyanins) Analyses:

Dr. Gary Gao explored various analytical methods of antioxidants including anthocyanins. He met with staff members of OSU Campus Chemical Instrument Center and Targeted Metabolite Center. Dr. Gary Gao met with several research chemists at OSU and Central State about the most efficient ways to measure anthocyanins and other antioxidants. Dr. Gao was able to find Ms. Yucheng Zhou, who was a recent graduate of food science from Dr. Monica Giusti's lab at The Ohio State University. After receiving approval for hiring this person since she is a foreign national, we hired Ms. Zhou in

October, 2015. She processed and analyzed our fruit samples with HPLC and spectrophotometer. We purchased a Minolta Colorimeter with some funds from the grant and some matching funds from OSU South Centers. Our research team has used it in the field to measure fruit color and screen fruits for their color intensity and antioxidant content.

1.3: Gather Research and Production Information

Dr. Gary Gao attended the 2015 ASHS Annual Meeting in New Orleans, LA. He attended quite a few sessions on super berry production. He also talked with some of the top researchers and extension professionals on super fruits and their health benefits. It turns out that *Aronia* is not a berry and is more related to pome fruits, such as apple. He attended several sessions on analyzing anthocyanins and other flavonoids. This information has helped our research team in chemical analyses and fruit screening for enhancement of pigments and antioxidants.

2. Grower Outreach

Grower outreach was one main focus of our grant activities. We used many different approaches in reaching a very diverse in a large state since fruit growers are scattered all over the State of Ohio. A few growers have plants *Aronia*, blackberries, and Chinese goji berries. We gathered new acreage information in 2016 by interviewing growers and extension educators.

2.1. Grower Workshops

A. Annual Meetings and Summer Tour of Grower Associations

Ohio Produce Growers and Marketers Association (OPGMA)'s Congress and Summer Tour:

Dr. Gary Gao made two presentations to about 65 growers on super berries the 2016 Annual Congress of Ohio Produce Growers and Marketers Association. He also attended the 2015 Ohio Produce Growers and Marketers Association's annual meeting in Sandusky, Ohio. He talked to about 45 growers about super berry production at the Congress. Dr. Gao was one of the featured speakers at the 2015 OPGMA Farm Tour. He talked about blueberries, which is one of the super berries. The attendance was 210.

Annual Meeting of Ohio Ecological Food and Farm Association

Dr. Gary Gao gave a talk on super berry production at the Annual Meeting of Ohio Ecological Food and Farm Association. His presentation drew approximately 55 attendees.

B. State, Regional and County Programs

Dr. Gary Gao gave a presentation on super berry production at the 2015 and 2016 Farm Science Review, which is an annual showcase of research projects and extension programs of the College of Food, Agricultural, Biological and Environmental Sciences, The Ohio State University. His presentation was held at the Small Farm Center and drew a combined attendance of 75.

Dr. Gary Gao taught several fruit production classes, which included five for a county extension program, one for Farm Services Agency and one for a garden center. The combined attendance for these seven programs was 206.

C. Ohio Super Berry and Wine Grape Workshop, and Super Berry and Wingrape Field Night

Dr. Gary Gao and his team hosted "Ohio Super Berry and Wine Grape Workshop" in March, 2015 and "Ohio Super Berry and Wine Grape Field Night" in August, 2015. The combined attendance for these two programs was 85. In March 2016, Dr. Gao and the members of his super fruit team organized the "Ohio Super Berry and Wine Grape Workshop," which drew 40 attendees. We also organized "Ohio Super Berry and Wine Grape Field Night" in 2016. The programs drew 32 attendees.

2.2. Research Tours

Our research plots of super berries at OSU South Centers were the main focus of research tours by new and existing growers, researchers, extension professionals, students, OSU administrators, and legislators. Our research plots were established with current and previous SCBG funds. Dr. Gary Gao and our research support team members offered 32 tours of research plots from late 2014 to late 2016 to approximately 650 people at OSU South Centers in Piketon.

2.3. Farm Visits

Dr. Gary Gao made 31 visits to fruit farms that grew many kinds of super berries from September 1, 2014 to September 30, 2016. These visits represented at least 400 acres of fruit production. He provided production tips, diagnosed problems and research updates to new and existing growers.

2.4. Social Media

An "Ohio Super Berries" Facebook page was created in summer, 2015. As of November 23, 2016, there were 211 "likes." Dr. Gary Gao has shared articles, pictures, videos, and links to website with the readers. Three videos have been created for our super berry project**.** They are uploaded to our super berry page at **http://southcenters.osu.edu/horticulture/fruits/super-berries** The videos are also available through our OSU South Centers' YouTube channel. In 2016, Dr. Gao appeared on a TV show at the University of Rio Grande. The show is called Ag. Talk.

Goals & Outcomes Achieved

1. Expansion Of The Super Berry Acreage:

The project goal of adding at least 30 acres of existing super berries, such as blackberries, blueberries, and raspberries from 2014 to 2016 has been achieved based on our interviews with growers and county extension educators. With existing super berries, planting acreage varied a lot. Planting of blackberries with winter protection using rotatable cross arm trellis showed the biggest jump! One grower planted 7 acres of blackberries while others have planted blackberries more in the range of 1-5 acres. New plantings of blueberry and raspberry are also in the 1-5 acre range. We are excited to report that several growers are planning to plant a total of at least 60 acres of existing and new super berries in 2017 or 2018.

Our Super Berry research and extension efforts have generated strong interests in both new and existing super berries despite the aftermath of polar vortexes in 2014 and 2015. Since it

can be quite expensive to establish fruit plants, we saw some new super berry plantings and a lot more acreage is being planned for 2017 and beyond.

At least 20 growers planted new super berries. It is estimated that at least 10 acres of new super berries, such as Aronia berries, elderberries and Chinese goji berries, were planted in Ohio from 2014 and 2016. All of the plantings were quite small. The largest planting is about 1 acre. The larger plantings are mainly located in the northern half of the state. The remaining plantings are scattered all over the state.

2. Identify Two Superior Elderberry And Aronia Cultivars For Ohio Growers Based On Their Growth Habits, Ease Of Propagation, Yields And Fruit Color:

Our project team has accomplished this project goal of identifying two superior *Aronia* and elderberry cultivars. Two superior elderberry cultivars identified for Ohio were 'Adams' and Wyldewood.' 'Johns' and 'Nova' are also quite good. Refer to Tables 1 and 2 for more information.

Table 1. 2015 Yield data of American Elderberries at OSU South Centers in Piketon, Ohio

Cultivar	1st Harvest (lbs/Plant) (8/19/2015)	2nd Harvest (lbs/Plant) (8/26/2015)	3rd Harvest (lbs/Plant) (9/3/2015)	4th Harvest (lbs/Plant) (9/10/2015)	Total Yield Per Plant (lbs)	Total Yield Per Acre (lbs/acre)
Adams	0.85	0.53	0.14	0.15	1.67	1209.28
Johns	0.83	0.73	0.16	0.11	1.83	1330.83
Nova	0.41	0.21	0.17	0.13	0.92	672.24
Wyldewood	0.51	0.52	0.50	0.31	1.84	1334.57
York	0.44	0.41	0.06	0.20	1.11	811.00

Table 2. 2016 Yield data of American Elderberries at OSU South Centers in Piketon, Ohio

Harvest Date	**Cultivar**	**Total Wt. (Kg)**	**Total Wt. (lbs)**	**Avg. lbs./plant**	**Total lbs./ac.***	**$ Price/ac. at $0.50 - $3.50/lb. Fresh or Frozen**
8/30/2016	Adams	16.30	35.93	2.99	2176.82	$1,088 - $7,616
	Johns	13.26	29.22	2.44	1770.52	$885 - $6,195
	Nova	8.50	18.74	2.68	1946.67	$973 - $6,811
	Wyldewood	12.91	28.46	2.37	1724.04	$862 - $6,034
	York	5.09	11.21	1.25	905.74	$452 - $3,167

Two superior *Aronia b*erry cultivars are 'Nero' and 'Viking.' 'Autumn Magic' can be a third choice for commercial growers for its large fruit size. However, the bonus feature of this cultivar is its red fall foliage color. Foliage color may be more a more important factor to

consider for home gardeners than for commercial growers. Researchers with the University of Missouri have selected 'Wyldewood' and 'Bob Gorgon' for their excellent adaption for the Midwest. We did not get enough 'Bob Gordon' plants for a replicated trial and do not know for sure how well it will perform in Ohio.

Aronia cultivars are very limited. Most, if not all of the named cultivars, were selections from the wild or commercial plantings. There were mainly two *Aronia* cultivars. They are 'Nero' and 'Viking,' and a few researchers think they are of the same genotype. Both cultivars performed well in our trial and limited grower trial.

We have also screened two goji berry cultivars and a few seedlings. The commercially available goji berry cultivars in the US are 'Crimson Star' and 'Sweet Lifeberry.' 'Sweet Lifeberry' is a sweeter tasting berry than 'Crimson Star.' Dr. Gary Gao visited the goji berry production area in China on a separate project. He learned that 'Crimson Star,' known as 'Ningxia #1' in China, was six generations behind the leading goji berry cultivars in terms of fruit size and taste. We need to import the leading goji cultivar in China. However, that takes a lot of paperwork and a few years to accomplish.

On the brighter side, one of the nursery growers in Ohio identified a promising selection from some goji berry seedlings. We propagated a few plants from this selection and will continue to work with it to see how much commercial potential it holds.

It should be noted that successful breeding, selection, and introduction of new cultivars require many years of local trials. Perspective growers should still do their own trial before a large planting is installed since soil conditions and climate can vary a great deal from one site to next, even in the same state.

3. Increase The Awareness Of Super Berries Among Growers:

3.1 Press Releases

We achieved our goal of publishing at least eight press releases about super berries during the two years of this grant. These press releases were sent to numerous news outlets in Ohio and beyond. These articles reached at least 250,000 consumers in Ohio during the 2-year grant period.

Some of the examples are:

a. **Super Berries in Ohio in Edible Columbus on June 20, 2016**
   http://www.ediblecbus.com/blog/6/20/y/super-berries-in-ohio
b. **Super Berry School is March 18, 2016**

http://www.growingmagazine.com/fruits/super-berry-school-is-march-18/
https://ofbf.org/events/super-berry-school/

c. **Super Fruits at the OPGMA 2016 Congress**
   http://opgma.org/resources/Documents/Session%20Grid%20.pdf
d. **AGRI-TALK - Dr. Gary Gao- SUPERFRUITS - Healthy Living February 13, 2016 1:00 pm** http://www.blogtalkradio.com/a-patrick-dengel/2016/02/17/agri-talk--dr-gary-gao-superfruits--healthy-living-february-13-2016-100-pm

e. **Super Fruits/Berries at the 2016 Beech Creek Garden Symposium** http://www.beechcreekgardens.org/wordpress/wp-content/uploads/2015/12/BC-Garden-Symposium-2016.pdf
f. **Super Fruits at the 2016 OEFFA Annual Meeting** http://www.oeffa.org/pdfs/2016_workshops_1-12.pdf
g. **2016 Super Berry Workshop on Ohio Grape Web** http://ohiograpeweb.cfaes.ohio-state.edu/sites/grapeweb/files/imce/pdf_newsletters/OGEN20161503(07).pdf
h. **Super Berries Production Workshop Offered March 19, 2015** http://cfaes.osu.edu/news/articles/super-berries-production-workshop-offered-march-19
i. **2016 Farm Science Review Coverage by Madison Press** http://madison-press.com/wp-content/uploads/2016/09/LMP091616S.pdf
j. **A Super Time for Super Berries - 2015** http://vegnet.osu.edu/sites/vegnet/files/imce/newsletters/VegNet/6.15.15VegNet%20Newsletter.pdf
k. **2015 Blueberry, Brambles and Winegrape Production Workshop Offered July 15** http://cfaes.osu.edu/news/articles/blueberry-brambles-and-winegrape-production-workshop-offered-july-15
l. **2015 "Super Bowl**:" http://sustainability.cfaes.ohio-state.edu/on-the-farm/super-bowl/
m. **2015 OSU Farm Science Review Flyer:** http://fsr.osu.edu/sites/fsr/files/imce/OSU%20Schedule.pdf
n. **Ohio fruit expert encouraging farmers to grow superberries (October 25, 2015)** http://www.farmworldonline.com/news/ArchiveArticle.asp?newsid=20182

3.2 Super Berry Fact Sheets

We achieved our goal of writing one fact sheet each on Aronia berries, elderberries, and goji berries. These fact sheets were made available to program attendees in 2016. They will also be posted online on our website.

3.3 Regional Workshops

We have reached our goal of organizing three regional workshops each year and drew a total of 100 attendees during the two years of this project. Our Super Berry Workshop and Super Berry Field Night in both 2015 and 2016 were very popular. They workshop alone drew a total of 120 attendees are expected to be reached through these regional workshops.

We also worked with grower associations and extension professions across the state of Ohio to offer presentations at their annual meetings and winter meetings. Some of the examples are OPGMA Congress and Summer Tour, OEFFA Annual Meeting, Southwest Ohio Fruit and Vegetable School, Farm Science Review, Beech Creek Garden Symposium, OSU South Centers' Open House. These programs drew a combined audience of 780!

Figure 1. Ryan Slaughter, research assistant at OSU South Centers, is shown here to talk about elderberry production at the 2015 Super Berry and Wine Grape Field Night. Photo by Kaitlyn Williams

Figure 2. Drs. Gary Gao (Small fruit specialist) and Tom Worley (Director of OSU South Centers) welcomed Super Berry and Wine Grape Field Night Attendees at the OSU South Centers in Piketon, OH. Photo by Ryan Slaughter.

Figure 3. Dr. Gary Gao, Ryan Slaughter and Michael Daniels showed program attendees our newly planted Chinese goji berry plants at OSU South Centers in Piketon. Photo by Kaitlyn Williams, OSU South Centers.

Figure 4. Dr. Gary Gao answered questions on blueberry cultivars and production techniques, Photo by Ryan Slaughter, OSU South Centers.

3. **Develop an Efficient Method Of Propagation Of Aronia Berries, Elderberries, and Goji Berries:**

4.1. **Elderberries**

We reached our goal of 80% or higher success rate with propagating elderberries. We concentrated our efforts on elderberry propagation since there are more elderberry cultivars. We also needed to propagate elderberry plants from cuttings for our cultivar trial.

We used a potting mix of Pro-mix and pine bark media 50:50 by volume. 'Wyldewood' was our test cultivar. We took 3-node dormant cuttings. They were approximately 8" long. The third node on the bottom end of the cuttings had a 2" stub. All of the cuttings were stuck in a grape lug with the potting mix.

Figure 5. Shown here are rooted elderberry plants in a grape lug. Photo by Ryan Slaughter

Figure 6. Shown here are rooted elderberry plants in 5" square pots. Photo by Ryan Slaughter

The bottom node was covered with the potting mix. All of the new roots arose from the bottom node. Stems came out of the top two nodes. Our grape lugs with cuttings in the potting mix were placed in mist bench, which was set on a timer of misting once every half an hour.

In summary, dormant elderberry cuttings can be rooted easily in a Promix and pine bark mix. We reached a rooting rate of at least 88%.

4.2 Red and Black Chinese Goji Berries

We tried to propagate goji berries with both seeds and cuttings. Red Goji Berry seeds were either soaked for 24 hours prior to planting in room temperature water or planted as is at depths of 0.25 inches or 0.5 inches in Pro-mix potting media. Soaked seeds covered with 0.25" of potting mix was the best combination and gave us an 88% germination rate.

Table 3. Red Goji Berry Seed Germination Rate

Red Goji Berry Seed Germination Trial				
	Dry vs. Soaked and Planting Depth			
	Dry 0.25"	Dry 0.5"	Soaked 0.25"	Soaked 0.5"
% Seed Germination After 7 days	68%	44%	88%	12%

Black Goji Berry Seeds were soaked for 24 hours and planted at 0.25 inches in Pro-mix potting media; the germination rate was 57%. We do not know if it was poor seed quality or black goji berry seeds are different than those of red goji berries.

Three-node cuttings were taken from Red Goji Berry plants, treated with a rooting hormone and planted in Pro-mix potting media. Rates of root formation were less than 50%. More work may be needed.

4.3. *Aronia* Berries

We did not conduct a trial of *Aronia* propagation since it was reported to be very easily propagated from softwood cuttings, divisions and seeds. Several growers had good experience with propagating *Aronia* plants on their own.

5. Direct Support Of New And Existing Super Berry Growers To Help Create And Retain Jobs:

We exceeded our goal of educating a total of 300 growers each year through presentations at the Ohio Farm Science Review, Ohio Produce Growers and Marketers Association Congress and Summer Tour, and OSU Extension County programs. We educated at least 780 farmers from 2014 to 2016. Dr. Gary Gao also visited 31 farms in Ohio during the same period. He helped growers solve numerous production problems.

It was quite hard to gather data on jobs created and retained. We will use blackberries as an example. Blackberry yield was excellent in 2016. We recommended 'Chester Thorneless' as a winter hardy cultivar for Ohio. In 2016, the total yield per acre for 'Chester Thorneless' in Piketon Ohio was 8,839 lbs (Table 4). At $3.00 a pound, one acre of blackberries in open field can generate more than $26,000 per acre. With more

than 300 acres of blackberries in open field in Ohio, our efforts definitely helped retain at least 50 jobs.

Table 4. Blackberry Cold Hardiness Variety Comparison Study in 2016

Polish Blackberry Winter Hardiness Trial Season Totals and Expected Yield/ac.				
Variety	**Season Total (g)**	**Sesaon Total (lbs)**	**Average lbs./plant**	**lbs/ac.**
Chester	103660	228.53	15.24	8839.2
Gaj	28677	63.22	4.21	2441.8
Natchez	17530	38.65	2.58	1496.4
Ouachita	33002	72.76	4.85	2813
Polar	26170	57.7	3.85	2233
Ruczaj	12921	28.49	1.9	1102
97521	16813	37.07	2.47	1432.6

Table 5. 2015 Blackberry yield data at OSU South Centers in Piketon, Ohio

Cultivars and Production Systems	Total Yield (lbs/acre)
Ouachita (Open Field Production)	0
Natchez (Open Field Production)	14.49
Ouachita (High Tunnel)	2908.58
Natchez (High Tunnel)	850.54
Ouachita (Rotatable Cross Arm Trellis)	520.42
Natchez (Rotatable Cross Arm Trellis)	75.44

There are also 70 acres of blackberries under rotatable cross arm trellis. This kind of blackberry system is reported to generate $45,000 per acre in gross revenue. The blackberry production using winter protection with rotatable cross trellis has helped Ohio retain 30 to 50 jobs.

Most of the new super berries were harvested and used in value added products, such as pies, jams, jellies, and wine. It is estimated that added acreage of new and existing super berries helped growers generate 20 new jobs in Ohio from 2014 to 2016.

Beneficiaries

We significantly raised the awareness of new super berries, such as Aronia berries, elderberries, and goji berries among consumers and growers through our research and outreach efforts. Twenty new growers new super berries. The combined acreage was at least 10 acres. Three growers entered the super berry propagation business. They are expected to produce around 100,000 plants in 2017 and beyond. The acreage of other traditional super berries, such as blueberries, brambles, and Ribes, was increase by a total of 30 from 2014 to 2016. Another 60 acres of super berries are expected to be planted in 2017 and 2018.

Our comprehensive Extension outreach programs helped growers reduce crop loss from improper pruning techniques, poor cultivar selection or planting techniques, excessive or under-application of fertilizers, damaging insects, diseases, and nuisance wildlife, and competition from weeds. Our educational efforts on best management practices, season extension methods, and innovative production systems definitely helped 1,200 berry farmers stay competitive and help Ohio's 2,500 fruit growers diversify their operations. The results from research trials and grower support programs helped create at least 20 jobs and retain 50 existing jobs from 2014 to 2016.

Lessons Learned

We found that it was much more difficult to promote new super berries, such as Aronia, Chinese goji and elderberries since they are not typically consumed as fresh fruits. Growers needed to develop the processing capacity before large plantings of new super berries can be installed. Growers needed to work with companies like J.M. Smucker in Orriville, Ohio to process their crop. In the meantime, they need to use what they grow in their own value added products. That certainly limits their production capacity. It was indeed much easier to promote existing super berries, such as blueberries, blackberries, and raspberries since they have health benefits, excellent taste, and high yields.

We also found out that adverse weather conditions were very detrimental to existing super berries, such as blackberries, blueberries, and raspberries. "Polar vortexes" in 2014 and 2015 definitely hurt fruit yields in Ohio and beyond! Fortunately, we researched and promoted the blackberry production system using rotatable cross arm trellis and row cover as winter protection. Even through it costs about $20,000 an acre to establish, several growers have planted five acres on the smaller side to 20 plus acres on the large side.

We also learned that detailed chemical analyses require years of comprehensive training and the state of art equipment. We did the best that we could have with the funds available.

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Additional Information

Soil Media:

1. https://www.facebook.com/OhioSuperBerries/
2. https://www.youtube.com/user/southcenters